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OF THE INSTITUTION OF ELECTRICAL ENGINEERS

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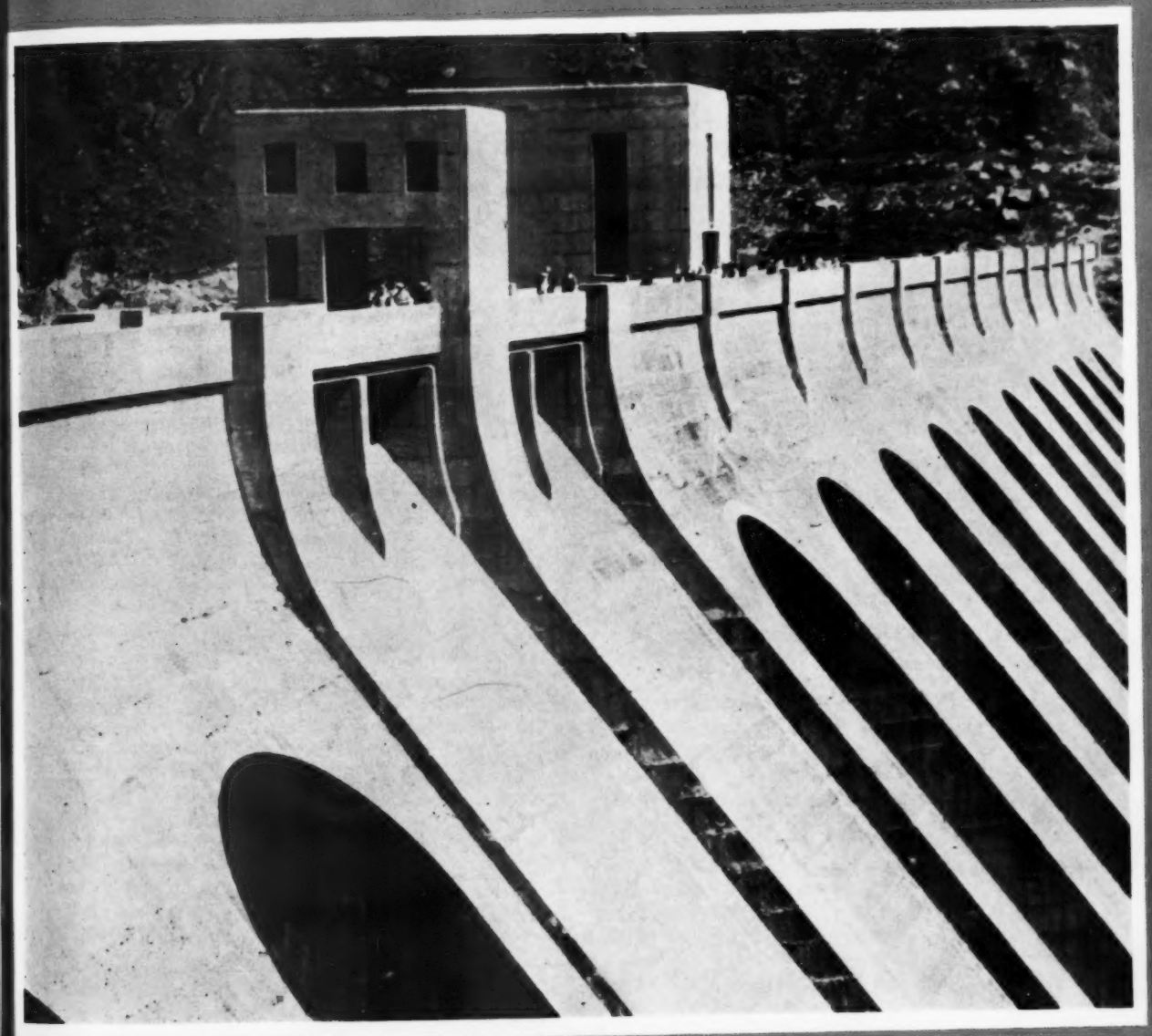

VOLUME 6 NUMBER SIXTY-NINE SEPTEMBER 1960

JOURNAL OF THE INSTITUTION OF ELECTRICAL ENGINEERS

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A DAM IN DUNBARTON

SHOWN in the cover picture this month is the dam at Loch Sloy. It is of the massive buttress type, 160ft high and 1160ft long. The water is led to the power station on the shores of Loch Lomond by means of a main tunnel, 15ft 4in. in diameter and two miles long, and four pressure pipelines 7ft in diameter.

The people on the dam are members of The Institution and their ladies, taking part in one of the many visits at The Institution's Summer Meeting based on Glasgow from the 27th June to 1st July 1960, an account of which appears on p. 532

Secretary W. K. BRASHER, C.B.E., M.A., M.I.E.E. *Editor* W. G. ASKEW, M.C.
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JOURNAL

OF THE INSTITUTION OF ELECTRICAL ENGINEERS

SAVOY PLACE LONDON W.C.2 VOLUME 6 NUMBER 69 SEPTEMBER 1960

LETTERS FREE AND EASY

LETTER-WRITING is not an art that comes easily to most people. Even more difficult than a letter to an aunt or a cousin is a letter to the Editor. A few folk find it simple enough, but for most of us the native hue of resolution is soon sicklied o'er with the pale cast of thought.

This is often, though not always, a pity. The expression of opinion, the progress of argument, the straightforward communication of new information—these are the very stuff of social and scientific advancement. The flint, the steel, the fuel may not be much in themselves, but together they make a lovely light.

Thus it is the Council's desire to stimulate correspondence in the publications of The Institution. Apart from the letter which arises directly from a previously published statement or opinion (the cement, so to speak, of a decent debate), there are two types of correspondence which ought to be encouraged.

The first is the frank and sincere exposition of a valid view about The Institution itself, its policy and affairs. If brief and to the point, letters of this nature published in the *Journal* help the general membership to establish a climate of opinion on important issues. But let them be free and easy, not forced or strained, for compulsive controversy is a bore. Not all letters in this category are suitable for publication in the *Journal*, even where they meet the above criteria, for obvious reasons. But as liberal a publication policy as possible should be pursued.

The second kind is concerned with The Institution's prime objects—the promotion of the general advancement of electrical science and engineering and their applications, and the facilitation of the exchange of information and ideas on these subjects. The formal paper is usually needed here, but there are many occasions when the brief letter or note serves a useful purpose, by giving advanced notice of the 'red-hot' results of some work, later to be published as a full-length formal paper; or by expressing a new concept or theory or just a helpful idea; or by expounding a practical problem, with or without its solution, encountered in the development, manufacture, operation or maintenance of equipment.

The correspondence columns of the *Journal* are open to both the letter on Institution affairs and the letter on a scientific or technical topic. Subject, in cases of doubt, to the approval of not more than one referee, and often without even this proviso, such letters are accepted at the Editor's discretion and are published without delay.

For scientific or technical subjects, similar provision is made in the *Proceedings*. Here some slight delay is unavoidable, because scrutiny by a referee is insisted on, and because Parts A and B are published only in alternate months. However, delay due to mechanical reasons is slight, for a short contribution, received at the last minute, can often be inserted in what would otherwise be a blank space.

Whether a particular item appears as a letter in the *Journal* or as a communication in the *Proceedings* depends largely on whether the topic is of wide general interest or of appeal to the specialist alone, and also on whether the matter is of ephemeral interest or is intended for the permanent record of The Institution. In border-line cases, and preferably always, the writer should indicate his choice of medium; every endeavour will be made to meet his wishes. Although it was as long ago as 1949 that the *Journal* of The Institution became the *Proceedings* and gave its name to the new monthly *Journal*, items obviously intended for the *Proceedings* are still occasionally addressed as though they were meant for the *Journal*. This minor difficulty is not insuperable, but it could conceivably cause a little delay.

A suitable length for a letter in the *Journal* is about 300 words, though up to 1000 words can be accommodated in special cases, For a communication in the *Proceedings*, an upper limit of 1500-2000 words, with or

without illustrations, has been suggested. As a rule, a longer article (a short paper, > 2500 words) would need to be divided into sections and preceded by a summary. It would have most of the marks of a formal Institution paper and would usually be treated as such —submitted to three referees and, 99 times out of 100, returned to the author for revision. Unlike a contribution, a paper starts at the top of a page and not half-way down; for this and other mechanical reasons, the revised manuscript would have to take its place in the queue.

In the *Proceedings*, each contribution to a discussion is limited to about 300 words and must be strictly relevant to the subject of the paper in question. But one thing suggests another, and a contributor may find that he has something to say which, although irrelevant in that context, might be suitable as a contribution *per se*. Of particular value to those members who serve as the Council's representatives on various committees of the British Standards Institution would be suggestions for specifications, definitions and symbols—suggestions inspired or prompted by glancing through the pages of the *Proceedings*.

For all types of letter, it is suggested that informality should be the keynote. Let expression be unconfined and untrammelled, though not verbose or libellous. The innocent opinion, even if misconceived, can often illuminate a dark corner; and free and easy communication should be the mark of an Institution which began life as the Society of Telegraph Engineers.

FACILITIES FOR MEMBERS IN CANADA

New arrangements with the Engineering Institute of Canada

For some time past, the Council of The Institution have been concerned about the inadequacy of the facilities provided for members of The Institution who are resident in Canada to take part in technical meetings; therefore they welcomed the appointment of a small committee by the Council of the Engineering Institute of Canada who were asked to consider a basis for co-operation with other Commonwealth societies with a view to meeting the needs of as many of the professional engineers resident in Canada as possible.

After receiving the report of this special committee, the Council of the Engineering Institute put forward the following proposals, which have been accepted with appreciation by the Councils of The Institutions of Civil, Mechanical and Electrical Engineers:

(a) Members of other Commonwealth societies resident in Canada are to be invited to participate in the activities of the Engineering Institute of Canada (EIC), both on a national and on a local basis. Branches of the EIC are to be encouraged to establish specialist Engineering Sections and/or specialist Engineering Discussion Groups wherever justified by numbers and interest

(b) All members resident in Canada are to be invited to submit papers for consideration by the appropriate Engineering Division of the EIC Committee on Technical Operations for presentation at annual, regional and local meetings of the EIC. They are also to be encouraged to submit papers of a more local character to the EIC Branch in each area

(c) Members of another Commonwealth society resident in Canada are to be represented on the appropriate Engineering Division of the EIC Committee on Technical Operations, where warranted and justified by the number in that speciality and as agreed by the society concerned, by a representative appointed thereto by the governing body of the sister society. Members so nominated are to become full voting members of the Division or Committee

(d) Where a Branch of the EIC has appropriate specialist Engineering Sections, members of sister societies resident in the area are to be invited to participate in local activities on the same basis as the EIC members in those Sections, and are to be represented in each case, where warranted and justified by numbers in that speciality and as agreed by the societies concerned, by a member appointed to the appropriate Section Executive, the appointment to be made by the sister society. Members so appointed are to become full voting members of the Section Executive

(e) Where a Branch of the EIC has appropriate Engineering Discussion Groups, members of sister societies resident in the area are to be invited to participate in the activities of the Groups of their interest on the same basis as EIC members

(f) Where a Branch of the EIC has neither an appropriate specialist Engineering Section nor an appropriate specialist Engineering Discussion Group, members of sister societies resident in that area are to be invited to participate in Branch activities on the same basis as EIC members

(g) Such members of other societies resident in Canada and wishing to participate in the activities of an EIC Branch will be billed by the EIC Headquarters in the amount of $3.00 per annum to cover the cost of meeting facilities, mailing notices, etc. They shall be eligible to receive the *Engineering Journal* at the same rate as EIC members, and the *Transactions* of the EIC at a cost of $1.00 per annum. Where reciprocity is accorded by the other Commonwealth society, members of the EIC resident in that country will be billed by that society for out-of-pocket service costs plus an additional charge at member rates for the publications of the society

(h) It is the hope of the Council of the EIC that members taking advantage of these arrangements will ultimately become members of the EIC.

Steps are now being taken by the Council of the Engineering Institute of Canada to implement these proposals, and a communication on the subject is being sent by the General Secretary of the Engineering Institute to each of our members with a Canadian address. The Council of The Institution hope that these members will give the scheme their whole-hearted support, in the knowledge that by so doing they can take part in an activity which will contribute significantly to the further development and progress of electrical science and technology in Canada.

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Trawsfynydd nuclear power station

Trawsfynydd was the fifth nuclear power station to be ordered by the Central Electricity Generating Board, and its construction was commenced in July 1959. Some of the advances made in design and technique since Calder Hall was commissioned in May 1956 are discussed in this article, which was inspired by one of the themes of Mr. H. Watson-Jones's Chairman's Address to the North-Eastern Centre entitled 'The changing scene', delivered at Newcastle upon Tyne on the 12th October 1959 and before the Tees-Side Sub-Centre on the 6th January 1960.

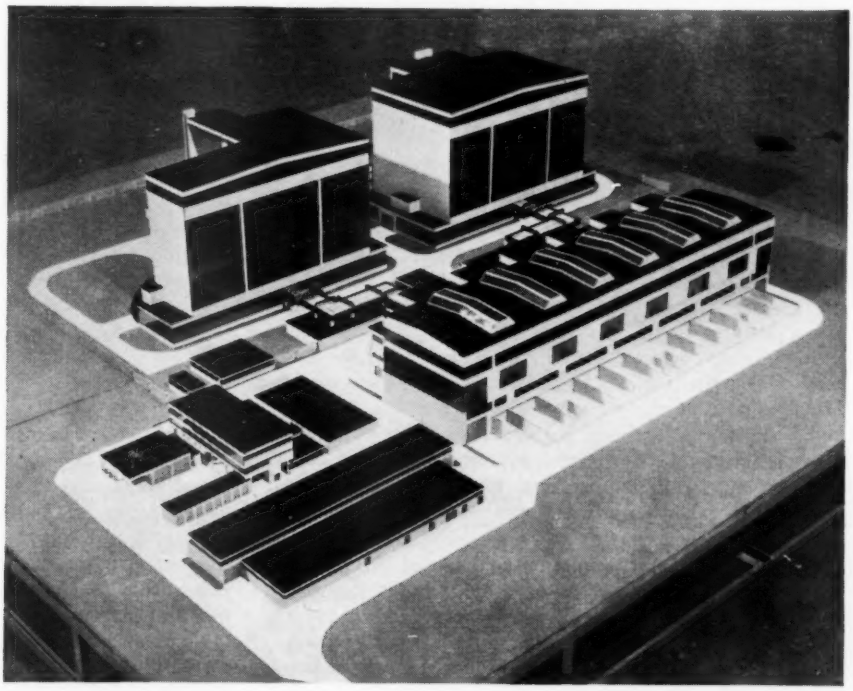
The author is a director of Richardsons, Westgarth and Co. Ltd.

H. WATSON-JONES, M.ENG., M.I.MECH.E., MEMBER

MICHAEL FARADAY is believed to have said 'We frequently learn more from our failures than our successes', and it is certainly true, in regard to heavy engineering, that the experience gained through previous major disasters and accidents has often proved invaluable in later designs.

In the field of nuclear engineering, however, we do not possess this advantage of previous hard experience, and the hazards from both technical and political points of view are such that we cannot afford to take the risks of such failures. This adds considerably to the responsibility of the many scientists and technologists, including metallurgical, civil, mechanical and electrical engineers, who are engaged in the design and construction of nuclear power stations.

In spite of this lack of previous experience, progress has been rapid in the short space of approximately four years since Calder Hall was commissioned. The first four commercial stations to be installed in Great Britain are now in an advanced stage of construction, and work began on a fifth station, at Trawsfynydd in North Wales, in July 1959.



1 *Model of Trawsfynydd nuclear power station, showing reactor buildings, turbogenerator house and administrative block*

Trawsfynydd, when commissioned, will have a total installed capacity of 580 MW. Table 1 gives the main technical parameters of the first five commercial stations and similar comparative data for Calder Hall and Chapelcross stations, which were designed primarily for plutonium production.

The site chosen for Trawsfynydd is in Merionethshire the nearest sea port being Portmadoc, some 11 or 12 miles away, which has been developed to allow many of the heavier items to be delivered by sea. The road to

Table 1. The first British nuclear power stations

	Calder Hall and Chapelcross	Bradwell	Berkeley	Hunterston	Hinkley Point	Trawsfynydd
reactor core						
no. of reactors	2 × 2	2	2	2	2	2
equivalent core diameter, ft	39	40	44	44·29	49	45
core height, ft	21	25·66	24	23	25	24·5
no. of fuel channels	1696	2575	3265	3288	4500	3270
reactor heat rating, MW	184	531	555	535	966	≃900
reactor vessel						
internal diameter, ft	37	66·75	50	70	67	61
thickness, in.	2	3 × 4	3	2·875	3	3·5
maximum working pressure, lb/in.² (gauge)	100	132·3	124·6	150	185	240
gas circulators						
no. of blowers per reactor	4	6	8	8	6	6
normal full load (each), h.p.	1500	3400	3150	2190	5210	6000
normal full speed, r.p.m.	854	3000	2740	1100	2550	2950
speed	variable	variable	variable	variable	variable	constant
type and control	centrifugal, Ward Leonard, d.c.	single-stage axial, variable-frequency	single-stage axial, hydraulic coupling	grid-controlled rectifier	axial-flow, variable-frequency	single-stage axial, by-pass throttle
heat exchangers						
no. of boilers per reactor	4	6	8	8	6	6
internal diameter, ft	18	19–20	17·5	≃23	21·5	18
height, ft	70	92·33	70	73	90·42	116
turbogenerators						
h.p. steam conditions:						
pressure, lb/in.² (gauge)	200	763	306	580	650	927
temperature, °F	397	707	612	700	685	715
l.p. steam conditions:						
pressure, lb/in.² (gauge)	53	199	62	150	177	290
temperature, °F	361	703	608	644	660	685
turbine cylinder arrangement	h.p. and l.p.	h.p. and 2 l.p.	h.p. and l.p. tandem	h.p. and l.p.	h.p. and 2 × 2 l.p.	h.p., i.p. and 2 × 3 l.p.
no. of sets	2 × 4	6	4	6	6	4
generator output, MW	23	52	85	60	93·5	145
total installed capacity, MW	2 × 92	312	340	360	561	580

the site has been reconstructed to carry the abnormal loads.

Unlike the first four commercial stations, which are sited on the coast and take their cooling water from the sea, the Trawsfynydd site is inland on the northern shore of an artificial lake of that name which was created about 30 years ago as the catchment reservoir for the neighbouring hydroelectric power station at Maentwrog. The lake is some three miles long and approximately a mile wide and will provide all the cooling water required. In fact, the quantity of water available from this lake and the allowable temperature rise are the limiting features as regards the ultimate capacity of the station.

The power station itself is on an exposed site and is being built directly onto a rock foundation 600ft above sea level. When completed, it will be connected by overhead line to the 275kV Supergrid system at the Ffestiniog pumped-storage station, which is being constructed five miles to the north. Since the site is within the North Wales National Park, careful consideration has been given to the design of the buildings to ensure that they blend with their surroundings (Fig. 1).

Reactor buildings

The station will comprise two reactor houses, each building containing one reactor and its six associated heat exchangers, or boilers. They will occupy an area of approximately 300 × 180ft at ground level and 179ft high, with a substructure extending 17ft 9in. below the finished ground level. The reinforced-concrete biological shield will vary in thickness from 10ft to 10ft 6in., forming a cylinder of 70ft internal diameter.

The nuclear fission of the uranium fuel is moderated by the graphite enclosure built within a steel pressure vessel containing CO_2 cooling gas under a pressure of 240lb/in.² gauge, the hot gas being then extracted and circulated through the heat exchangers which generate the steam required for conventional turbogenerating plant (Fig. 2). These spherical pressure vessels, each 61ft in diameter with a wall thickness of 3½in., together with many other items of equipment are being erected, welded and completed on site, and a travelling crane has been provided for this purpose. This crane is designed to lift a load of 400 tons to a maximum height of 200ft and travels the full length of the site on rail tracks 1200ft long.

Reactor core

Many thousands of accurately machined blocks of specially prepared graphite form the core of each reactor, which has a total weight of 1900 tons. There are 3720 vertical fuel-element channels in the core, each of which accommodates nine fuel elements consisting of magnesium-alloy cans containing natural-uranium rods. Projecting from the upper part of the pressure vessel are 241 standpipes for access to these fuel-element channels and to the control rods and shut-down devices etc.

Careful attention has been paid to detail and to the over-all proportions, including those of the reflector surrounding the active core. The result is a heat output of about 900 MW from a core 45 ft in diameter and 24 ft 6 in. high. This has been achieved without the use of exotic materials or significantly higher maximum temperatures in the core itself. The reactor outlet temperature of 400°C is nevertheless high enough to improve the steam conditions at the turbines, as compared with previous stations of the same type, and thus to provide a corresponding increase in the power generated from a given size of core.

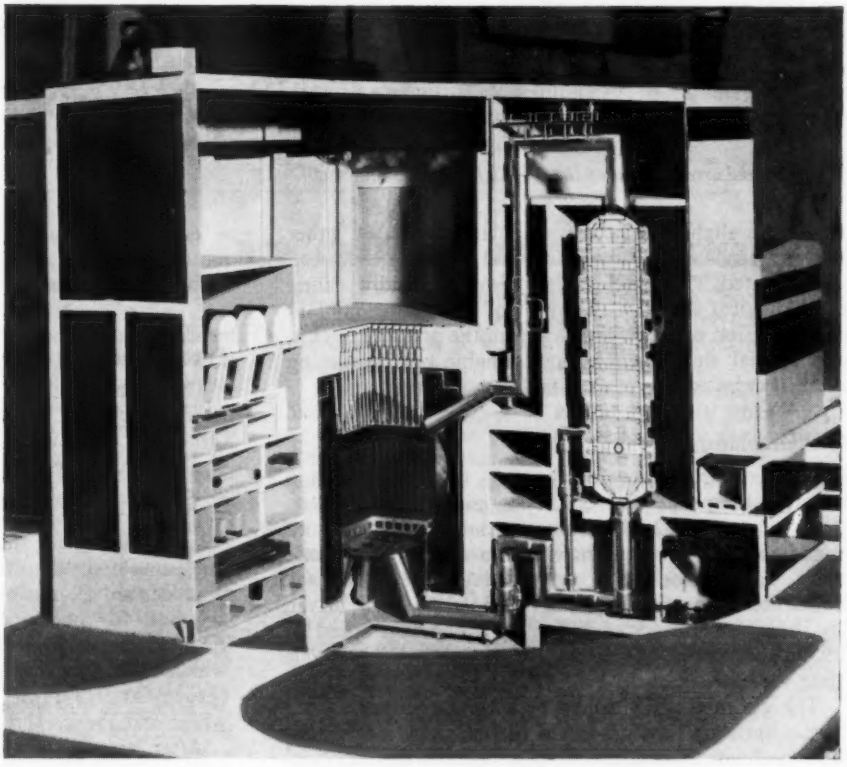
The CO_2, having given up its heat to the water and steam in the heat exchangers, is recirculated to the reactor vessel by large blowers, one of which is installed in each boiler circuit. Each boiler with its connecting gas ducts is individually shielded along its entire length by screening walls which connect with the biological shield of the reactor itself. The total weight of each reactor with its six heat exchangers and concrete shielding will be approximately 80000 tons.

Reactor control

All fuel-handling operations are carried out, with the reactor on full load and with gas pressure and temperatures in the pressure vessel at their normal values, by means of the charge/discharge machines provided, thus avoiding the necessity of shutting down the reactor whenever it is necessary to replace spent or damaged fuel elements. Two such machines are provided per reactor, each being designed to handle the fuel elements in any one of the fuel channels by remote control.

Each charge/discharge machine has a height of 60 ft and weighs 380 tons, including the shielded structure necessary to ensure that there will be no escape of radioactivity from fuel elements withdrawn from the core.

The station output is determined by the positioning of the 185 control rods in the reactor core. Provision is also made for an over-all automatic-control system using a signal from the steam pressure to control the CO_2 gas flow.



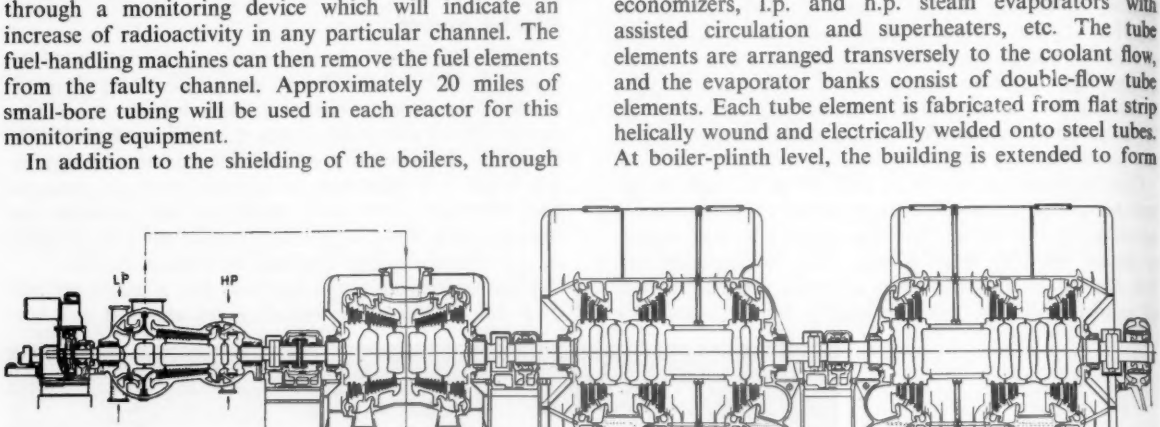
2 *Cut-away model of reactor building, showing reactor vessel and heat exchanger*

Safety

Should even the smallest leak develop in any one of the 33000 fuel-element cans, radioactive fission products

would be released into the cooling-gas flow. As an essential safeguard, therefore, samples of gas are taken every 20 minutes from each fuel channel and passed through a monitoring device which will indicate an increase of radioactivity in any particular channel. The fuel-handling machines can then remove the fuel elements from the faulty channel. Approximately 20 miles of small-bore tubing will be used in each reactor for this monitoring equipment.

In addition to the shielding of the boilers, through which the slightly radioactive coolant circulates, other important measures for additional safety have been incorporated. These include provision for rapidly sealing the biological shield in the event of radioactive coolant and/or fission products leaking from the pressure circuit, and special shut-down devices capable of functioning even in catastrophic reactor-fault conditions.



3 *Sectional arrangement of the 4-cylinder 145MW turbine*

Gas circulators

The gas circulators for the two reactors absorb a considerable proportion of the station auxiliary power. They comprise 12 single-stage axial-flow blowers of fundamentally new design with two sets of fixed-blade rings, each absorbing some 6000h.p. They are each contained in a spherical steel casing and are driven by induction motors operating at a constant speed of 2950r.p.m. and are therefore cheaper and more reliable than variable-speed drives.

The gas flow is controlled by a combination of automatic butterfly throttle valves in the main gas circuits and mechanically-coupled by-pass filters in the recirculating ducts to the blowers, resulting in an almost constant reactor-inlet temperature over the operating flow range. The valves themselves are controlled using a signal derived from any pressure change in the high-pressure steam.

Boilers

The six multi-tubular heat exchangers or boilers provided for each reactor are placed in two groups of three on opposite sides of the reactor. The boiler shells are 18ft in internal diameter and 116ft high, fabricated from $2\frac{1}{2}$in.-thick steel plate. A dual-pressure 927/290lb/in.^{2} (gauge) steam cycle is adopted, the boilers generating 65% of the steam at the higher pressure.

Each boiler contains six sets of tube banks for the economizers, l.p. and h.p. steam evaporators with assisted circulation and superheaters, etc. The tube elements are arranged transversely to the coolant flow, and the evaporator banks consist of double-flow tube elements. Each tube element is fabricated from flat strip helically wound and electrically welded onto steel tubes. At boiler-plinth level, the building is extended to form a common circulator house containing the electric motors for driving the gas circulators, which are located vertically below each boiler.

Turbogenerator plant

The turbine house is approximately 450ft long by 220ft wide and 96ft high. It contains four 145MW turbogenerators with their associated condensing and feed-heating plant and dump condensers, the turbogenerators being arranged across the axis of the house.

The turbines are four-cylinder machines (Fig. 3), designed for dual steam conditions, which, although low compared with modern conventional power-station practice, are an advance on what had previously been achieved for nuclear power stations in this country. Each machine comprises a high-pressure cylinder into which steam, having an initial pressure of 927lb/in.^{2} (gauge) at 715°F, is fed over a single-stage impulse wheel and thence through a multi-stage reaction rotor.

After leaving the last stage, the steam is mixed with low-pressure steam which has been expanded from the boiler l.p. conditions of 290lb/in.^{2} (gauge) 685°F through another impulse wheel. The blended steam then enters the double-flow intermediate-pressure cylinder and passes finally to two triple-flow l.p. cylinders and twin condensers. The feed water is preheated in three stages to 220°F, for which purpose steam is bled from the i.p. and l.p. turbines. The back pressure is approximately 0·563lb/in.^{2} absolute at maximum output of 145MW, which also gives the most economical operating condition.

To minimize exhaust turbine blade erosion caused by the comparatively high wetness of the exhaust steam, special steam-moisture separators will be provided

between the intermediate- and low-pressure cylinders. Each separator will be arranged in a casing mounted externally to the turbine. In addition, the low-pressure stages of the turbine are provided with the usual diffuser channels for removing moisture.

The turbo-alternators are each designed for 170 MVA at 0·85 power factor with a short-circuit ratio of 0·4. They generate at 16·5 kV, and step-up transformers connect them to the neighbouring C.E.G.B. 275 kV switching compound, thus feeding the net station output of 500 MW into the Supergrid system.

The alternators are hydrogen- and water-cooled, the rotors being direct-hydrogen-cooled through hollow copper conductors at a pressure of 30 lb/in.^{2} (gauge), while the stators are hydrogen-cooled with water-cooled stator windings. The 600 kW exciters are gear-driven from the alternators at a speed of 990 r.p.m.

Station control

Control of the whole station will be from a single central control room built integrally with the turbine house. In general, major items of plant, such as the turbogenerators and boilers, are started locally, but once the plant is running at power all operations are carried out from the central control room.

This houses all the controls necessary for the adjustment of reactor power and for the turbogenerators, together with indicators and recorders for essential pressures, temperatures and reactor plans, etc. Equipment is provided for the automatic control of the reactor instabilities using nine independent control-rod servo-systems operating from average values of the fuel-channel gas-outlet temperature.

Summary

Progress on the nuclear power stations being constructed at Bradwell, Berkeley, Hinkley Point and Hunterston was reviewed at the 1959 British Electrical Power Convention. Subsequent technical advances affecting reactors and blowers, heat exchangers and generating plant have been incorporated in the Trawsfynydd station. The results have been increased heat output from given reactor dimensions, larger generator units, and higher installed capacity.

NEW ROUTES TO ASSOCIATE MEMBERSHIP

The Associate

THE Council of The Institution have long been concerned that a number of engineers holding senior positions have been unable to transfer from the class of Associates to that of Associate Members by satisfying the educational requirements within the existing Regulations. The choice for such an Associate, between passing the Institution Examination and writing a thesis to demonstrate that his technical knowledge is equivalent to that required in the Examination, has not always offered him a suitable means of proving his academic competence.

The Council have now introduced an alternative, designed particularly for the older Associate, whereby he may be given permission to submit an engineering report and to attend an interview, in the course of which he will be asked to discuss his report. In their examination of the report and in the subsequent interview, the referees appointed by the Council will look for evidence of a broad outlook, a critical appreciation, a logical presentation of the subject, and a sound engineering judgment, and will question the candidate critically to make sure that he has a real appreciation of the underlying principles of his topic.

The standard imposed will be equivalent to that set by the whole of the Institution Examination, but will be related to the subject on which the candidate has been working and with which, therefore, he will be expected to be familiar.

Students and the Part III Examination

The Council have also studied the difficulty experienced by many Students in finding approved preparatory courses for the special subjects of the Part III Examination, and even for advanced electrical engineering. Where a candidate has passed or obtained exemption from Parts I and II of the Institution Examination and can satisfy the Council that he is unable to attend an approved preparatory course, this requirement will be waived, and he will be admitted to the Examination without submitting coursework.

Where the candidate passes in advanced electrical engineering and is engaged on engineering work which, in the opinion of the Council, would be suitable for presentation in a technical essay, permission may be given for a summary of such an essay to be presented; if this is approved, the candidate may write the essay, normally 3000–5000 words in length, on the engineering work with which he is intimately concerned, and present it for assessment as an alternative to passing in the special subjects of Part III.

Associated with the presentation of the essay, there will be an oral examination, during which the candidate may expect to be questioned critically on the matter contained in his essay. He should be prepared to explain the underlying reasons for any assumptions and statements made, and to show that he has acquired a good engineering background.

Publication

The regulations relating to the presentation of engineering reports by Associates, or of technical essays by Students who have passed, or have been exempted from, Parts I and II and advanced electrical engineering in Part III of the Institution Examination, are published in the Examination Regulations, and are available to members as a separate extract on application to the Secretary of The Institution. The Council believe that the above changes will remove a serious obstacle, which has prevented certain people from transferring to Associate Membership, without reducing the academic standard attached to Corporate membership, and trust that all who are eligible will take advantage of the new facilities.

An electrical engineering review

ENERGY METERS

621.317.785

Since electricity became available for supply to the public, the supply engineer has been concerned with the problem of how to charge for the energy provided. In this article, which covers energy meters for charging domestic, commercial and industrial consumers, the author reviews the various tariffs at present used, and their effect on the method of measuring electrical energy and the design of meters. Off-peak loads, power-factor clauses, and summation metering are included. Mr. Roscoe is with the North Western Electricity Board.

E. ROSCOE, J.P., MEMBER

WHATEVER the product to be sold, or the price to be paid, the goods must be measured in one unit or another, i.e. weight, dimensions, number, etc. The means of producing the commodity will affect the price, and different tariffs for different times of the day or periods of the year may be needed in order to encourage consumer purchases to suit production.

Some electricity supply tariffs involve only simple measurement of electrical quantities, while others require complicated and expensive instruments. A prepayment meter, for example, costs more than twice as much as a credit meter. But complicated measurement should not be expected to be made at the same cost as simple measurement, and designers of tariffs should bear this in mind. The cost of metering should be considered in relation to the revenue from the energy supplied.

Effect of tariffs on measurement of electrical energy

It remains a basic fact that electrical energy cannot be stored, except in small quantities, and must therefore be produced as required for consumption. Electricity was first supplied to the public for lighting purposes only, and the demand was almost exclusively during the hours of darkness and practically confined to the winter. This inevitably meant inefficient use of plant.

The problem of making the best use of the plant is still with the supply authority, especially now that its capital cost represents such high interest charges. An assortment of tariffs exists, varied according to changing circumstances, social habits and customs of the consumers.

It is naïve to suggest—as one sometimes hears—that a flat rate for kilowatt-hours only should be charged. The wide range of methods of charging for electricity does, however, complicate the problem of measurement. It is therefore inevitable that an article on energy meters will contain many references to tariffs, since one is a product of the other. Let us then consider the various tariffs for different types of consumers and the problems of their application so far as these affect measurement.

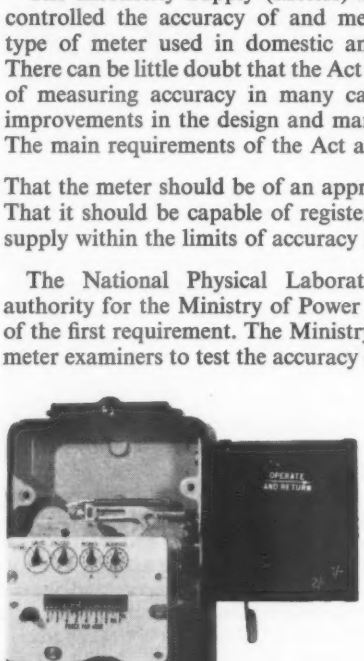
Single-phase meters and flat-rate tariffs

By far the greatest use of the flat-rate tariff is by domestic consumers, there being 17–18 million associated meters in Britain alone. Since the domestic-meter element forms the basis of practically all types of polyphase watt-hour meter, let us examine its design and performance.

The Electricity Supply (Meters) Act has, since 1936, controlled the accuracy of and method of testing the type of meter used in domestic and similar premises. There can be little doubt that the Act has raised standards of measuring accuracy in many cases and has led to improvements in the design and manufacture of meters. The main requirements of the Act are:

That the meter should be of an approved pattern and
That it should be capable of registering the value of the supply within the limits of accuracy laid down.

The National Physical Laboratory is the testing authority for the Ministry of Power to ensure fulfilment of the first requirement. The Ministry employ electricity-meter examiners to test the accuracy of the meters and to



1 *Single-rate prepayment meter*

certify that each meter before being installed complies with the second requirement. For this purpose, the examiners pay regular visits, usually at weekly intervals, to the Electricity Boards' testing stations.

The Act at present further requires that no meter shall remain in service for longer than 15 years. From a date specified in the Act, all existing meters on circuit had to be removed within ten years, which period has now been extended (owing to the recent war) to the 31st December 1962. Fifteen years is a long period for an instrument to register, accurately, units for which a charge will be made to consumers.

It is a credit to manufacturers and measurement engineers that meters will do this, keeping within the limits allowed ($3\frac{1}{2}\%$ slow to $2\frac{1}{2}\%$ fast) for all a.c. and d.c. types. The average labour cost of changing, repairing and testing a meter is approximately 26s. The national cost of changing 18 million meters amounts to approximately £24 million spread over 15 years, or £1 600 000 per annum. When the capital cost of building and equipment is added, this represents a substantial sum, and any improvement which will lead to an extension of the period of service life without loss of accuracy is to be welcomed.

Progress in design of meters

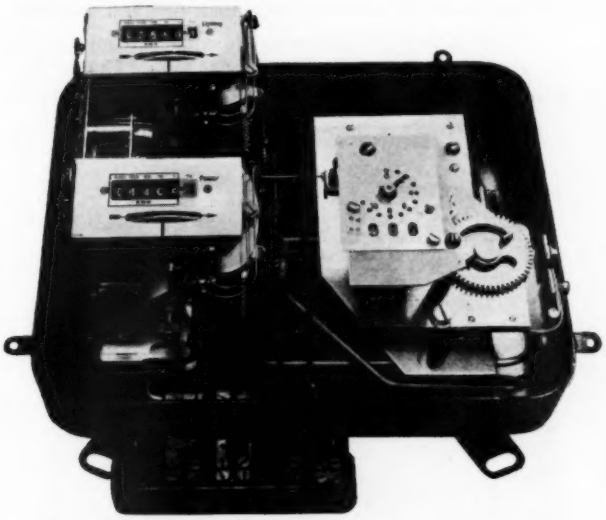
The better performance of new meters is mainly due to research and development in design and manufacture. Improvements in design and performance might be listed as follows, although these are not in order of importance since improvement of one part affects another:

1. Greater accuracy over a longer period and extended load range (from 20 : 1 to 60 : 1)
2. The torque has increased, mainly because of increased current rating, while the friction due to bearings and counting-train gearing has been reduced
3. Magnet size has been reduced, while the braking torque has increased, still retaining stability
4. In general, dials are easier to read, terminal connections are of sounder design and plastic cases give an improved finish.

Prepayment meters

Some consumers find it convenient to pay for electricity through a prepayment meter and thus avoid having quarterly accounts rendered. To meet this, a number of different types of meter have been made. It is possible to vary the cost of a kilowatt-hour and, in the case of the two-part-tariff meter, the fixed charge collected. The extended use of electricity for space-heating and floor-warming may cause a demand for easy-payment methods. A slump in industry, affecting economic conditions, also affects the demand for prepayment meters, which are generally installed in the houses of the lower-income group of consumers.

The capital cost is at present more than twice that of the credit type of meter, while the maintenance costs are much higher and the service life is shorter. This is not entirely due to failure of the meter mechanism but to false coins or discs inserted by consumers which jam the coin-receiver mechanism. There is also the problem of pilfering from such meters, causing damage which adds further to the cost of repair.



2 *Two-rate prepayment meter*

The different types of prepayment meter designed to suit the tariffs are as follows:

Single-rate meter (*Fig. 1*). This collects a flat rate or constant amount per kilowatt-hour. The price can be varied by a simple operation which changes the gear ratio between the disc and the tripping mechanism. Some makes are calibrated in kilowatt-hours per coin and others in coins per kilowatt-hour. The value of the coin can be 6d., 1s. or 2s.

Two-rate-tariff meter (*Fig. 2*). This is intended for use where there are normal and low-rate tariffs depending on the time of day when the supply is taken. It can be supplied as a prepayment or credit-type meter

Load-rate meter (*Fig. 3*). This meter charges one price up to a predetermined rate of consumption and a lower price for any kilowatt-hours consumed at a higher rate. This changeover is effected by a current-operated relay in the meter

Two-part-tariff meter (*Fig. 4*). In this meter both the meter disc and a continuously-operating synchronous motor drive through differential gearing to the tripping mechanism. A fixed charge is thus collected in addition to the charge for kilowatt-hours. Both rates are adjustable.

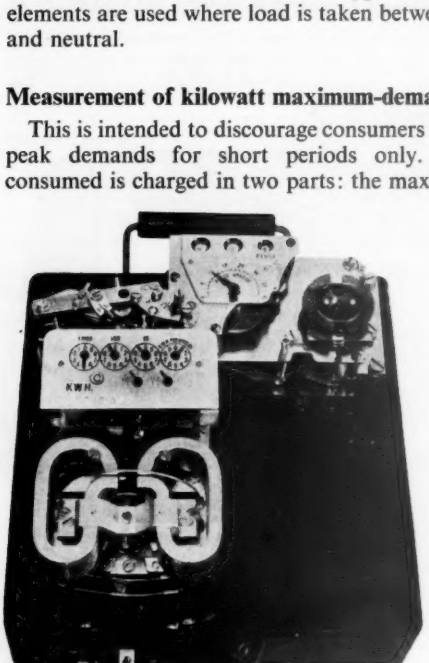
Consumers with 3-phase supplies, charged on kilowatt-hours only

These consumers require a 3-phase meter, which consists of two or three elements of the single-phase type driving onto a common disc or with discs coupled by a

spindle. Improvement in design has reduced the interaction between elements in this type of meter. Three elements are used where load is taken between any phase and neutral.

Measurement of kilowatt maximum-demand supplies

This is intended to discourage consumers from creating peak demands for short periods only. The energy consumed is charged in two parts: the maximum rate of demand in kilowatts measured over any half-hour during the month or quarter, and the total number of kilowatt-hours consumed during that month or quarter. Two-part kilowatt tariffs require the measurement of three quantities: kilowatts, kilowatt-hours, and time.



3 *Load-rate prepayment meter*

The Merz-type kilowatt maximum-demand system requires a geared attachment to a normal meter, in addition to the counting train. An idle pointer indicating the maximum travel of the driven pointer is reset every half-hour. The accuracy of the attachment therefore depends directly on the timing device, which in the case of a watt-hour meter divides kilowatt-hours by hours, resulting in the measurement of kilowatts. The time is measured by synchronous motor or by clockwork mechanism, depending for accuracy on frequency or good design and maintenance respectively.

The maximum-demand charge represents 25–40% of the total charge, and, for large supplies, pendulum-type clocks maintained to an accuracy of a few seconds per month are used.

Maximum-demand wattmeters operating on the thermal principle (see Fig. 5) are manufactured in the United States and Germany. These give a true indication of kilowatts. One of their advantages is that they do not employ a timing clock and therefore avoid this maintenance cost. There are, however, other considerations to be taken into account.

Effect of plant rating on measurement

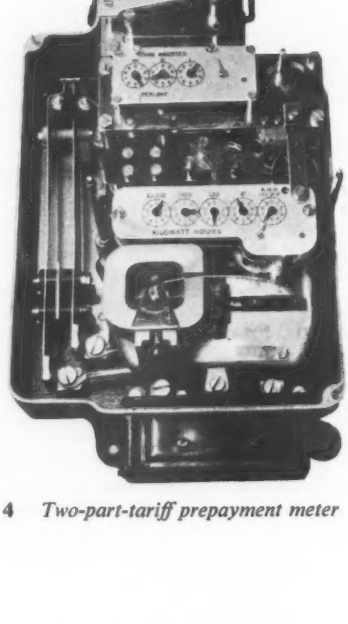
Electrical plant cannot always be rated in kilowatts: the ratings of cables and transformers, for example, are limited by the current that they will carry continuously. Some tariffs are based on the measurement of apparent power (kilovolt-amperes), which takes into account the losses due to low power factor not covered by a tariff based on kilowatts only. Meters to measure kilovolt-ampere-hours are therefore required.

The tariff for kVA maximum-demand supplies is designed to discourage the consumer from creating short-period peak demands. It is a two-part tariff involving kilovolt-ampere-hours and kilovolt-amperes. This latter requires also accurate measurement of time.

There are a number of meters available for the purpose:

1. An induction-current-operated kVA-meter, usually voltage-compensated
2. (Fig. 6) Meters which consist of two elements, one wattmeter (registering kilowatts) and one kVAr-meter, the measurements of which are vectorially added by gearing which registers kilovolt-amperes
3. A meter which measures kilovolt-amperes and kilovolt-ampere-hours. It employs a single-phase meter supplied by a transductor, the transductor a.c. flow being proportional to the arithmetical sum of the three rectified supply-line currents. The secondary currents from the line-current transformers are rectified in the meter.

Another type of maximum-demand meter, often



4 *Two-part-tariff prepayment meter*

referred to as a kVA pattern, is the thermal type. This is usually a maximum-demand ammeter which is calibrated in kilovolt-amperes and assumes a fixed voltage. It can also be calibrated in amperes. The deflection is caused by differential expansion of bimetal coils when heated by the passage of current, and follows a heating/time curve, the scale being non-linear. There is no clock, the timing period being governed by the time lag of the heating element in the meter, which is generally of the order of 15–30 min.

The Merz and thermal patterns of meter may not indicate the same demand if connected in series on the same variable load, owing to their different characteristics. The former has a straight-line characteristic of load and time; the latter follows an exponential curve.

The thermal maximum-demand instruments referred to above are sometimes fitted to single-phase meters for the larger domestic and smaller commercial consumers where two-part tariffs based on kilowatt-hours and kilovolt-amperes are employed. Since most domestic loads are taken at a power factor of unity, thermal maximum-demand meters would give a better approximation of the maximum demand than is given by rateable value or floor area. It might well be that such meters could find greater application with the greater use of electricity for domestic space-heating, especially if the capital cost did not prohibit their use.

Two-part kilowatt tariff with power-factor clause

A method of charging the consumer for losses due to taking energy at low power factor is to include a clause in the tariff which may reward the consumer for improving his power factor or penalize him because it is too low. In either case, measurement must be made of the reactive losses in the plant and cables. This can be based on the average power factor calculated from the monthly readings of a wattmeter and a kVAr-meter. The ratio of the readings from the two meters (kVAr/kW) gives tan ϕ, from which the average power factor can be derived.

Since the time when low power factor affects the supply authority's plant most is the time of maximum load on the plant, the power-factor clause may mean the power factor at the time of consumers' maximum kilowatt demand. A meter is available which measures reactive kilovolt-amperes at the time of maximum kilowatt demand (see Fig. 7). It is also useful to planning engineers for measuring feeder loadings.

It consists basically of a watt-hour meter with maximum-demand indicator and a kVArh-meter fitted with two indicators. By relay mechanism, the reactive demand of one indicator is locked in its indicating position when a maximum is established on the kilowatt dial. A higher kilowatt maximum locks the second reactive indication, releasing the first, and so on. At any time of reading, therefore, the locked reactive indication is the one that occurred at the time of the maximum-kilowatt-demand indication, but is not necessarily the highest reactive maximum.

Off-peak tariff metering

With the object of encouraging consumers to take energy when the load on the plant and cables is low, a reduced price is offered for consumption during that period. This requires control equipment operated by a clock, to switch off the supply during the restricted period or to change over the registration of units onto a different meter or register, at the time of changeover agreed in the tariff.

The special feature of such a time switch is that it should maintain accurate time to keep to the terms of

5 *Thermal maximum-demand wattmeter*

agreement. If the consumer is a large multiple store requiring after-hours shop-window lighting, arranged to switch on at 6 p.m., it is a breach of the agreement if the lights do not come on at the correct time. If the clock is of the synchronous-motor-drive pattern, it requires a spring reserve of say 8–10 hours, otherwise a failure of supply causes an error in time of switching and many visits are necessary to correct all the time switches involved. The tariff requires the lower price to be charged during Saturday and Sunday, and the clock must cater for this.

Since the maximum demand on the generating plant invariably occurs during the four winter months, November to February, a time switch is now available which changes over to the low rate for the whole of the summer period and starts to operate on and off peak during the four winter months.

A single meter known as the two-rate can be used to measure the load for on- and off-peak hours by an internal relay which changes over the gearing from one register to another on the same meter.

If the tariff prevents the consumer from taking load except at certain hours, as for after-hours shop-window lighting, the time switch opens the circuit directly through its own contacts or by a solenoid-operated contactor.

The scope of this article does not cover the problems involved in the installations to control the circuits, but they should have brief mention. All Factory Regulations must be complied with, as well as the Institution Wiring Regulations and any others which are applicable, in the premises where supply is given.

Fire-alarm circuits must be maintained alive at all times, as must lighting circuits for use by the watchman. The circuits in shops require to be divided between those for after-hours lighting and other circuits for normal use. These must be correctly installed and protected and the circuit for the clock-winding gear maintained alive. The control of some circuits presents interesting problems.

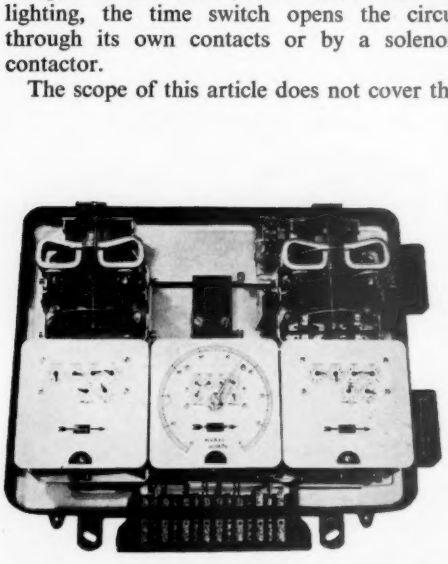
Summation metering

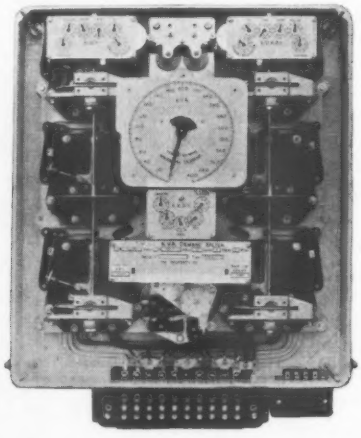
It is often necessary to measure the simultaneous maximum demand on a number of supplies separated by a short distance, as in the different parts of the consumer's premises, or by much greater distances such as C.E.G.B. points of supply to Electricity Boards, British Railways, etc. If a meter with printing device is installed at each point of supply, the addition of the meter readings for the corresponding half-hours at each supply point gives the simultaneous maximum demand.

An alternative is to add all the supplies onto one energy meter fitted with a maximum-demand indicator and/or printing device. This involves the running of pilot wires between the meter and points of supply. It can be used only where current-transformer-operated meters are in service.

There are a number of methods of summing two or more supplies, the choice depending on circumstances. The current-transformer secondary windings could be paralleled onto one meter current coil which would require a rating equal to the number of supplies to be measured multiplied by the current-transformer-secondary current rating. The voltage supplies to the meter should be common to all the supplies to be summed.

If there are only two supplies, two meters can be mounted vertically one above the other and fitted with a common spindle mechanically connecting all discs. These meters must have the same voltage supplies and the same current-transformer ratios. A number of polyphase meters are now arranged with two or three elements driving onto a single disc.





6 *Two designs of kVA-meter*

Two meters can be fitted side by side in one case, driving through differential gears onto a common register. The two supplies need not be of the same voltage, and the current-transformer ratios can differ.

The metering-current-transformer secondary windings can be joined to the primary windings of a special summation transformer, which has a primary winding for each supply fed from the secondary winding of the metering current transformer connected in each feeder. The secondary winding of the summation transformer is connected to a summation meter. The number of turns on the summation-transformer secondary winding is adjusted where the metering current transformers have different ratios. The voltage should be common to all supplies.

A meter in each feeder can be fitted with contacts on the spindle which cause electrical impulses to be transmitted to an impulse summator, which registers the total number of kilowatt-hours. The voltages and current-transformer ratios need not be the same.

In a more recent development, impulses are stored or transmitted electronically, and a series of plug-in units makes maintenance easy. The future may see much of this type of metering. It may be possible to sum supplies separated geographically by several miles. One wonders

whether radio links will ever be used for summation metering.

Metering of points of supply from C.E.G.B. to Area Boards

This metering may represent a money transaction of the order of £50 million per annum and requires great precision. The cost of a single equipment amounts to several thousand pounds. The measurement starts with a polyphase meter of precision grade which transmits electrical impulses onto summators which add or subtract to give net figures for kilowatt-hours supplied to the consumer.

This metering may be done at the power station, adding the energy supplied by each generator and subtracting that supplied to the station auxiliaries, and it may be subtracting energy supplied to another consumer along several feeders and finally giving the net figure to the one consumer to whom a charge must be made. (See Fig. 8.)

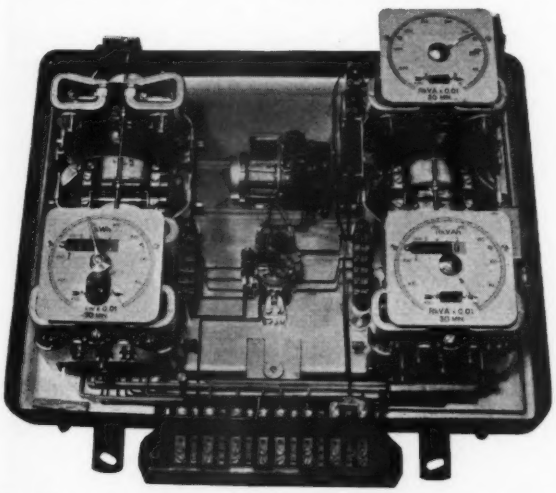
Special meters

Typical of special meters are those which measure core and I^2R losses of power transformers, and others which operate some alarm mechanism through demand-pointer contacts to assist consumers to limit their own maximum demand.

Instrument transformers

Modern transformers are more accurate and smaller, owing to the development of low-loss core material. It is now possible to obtain bar-primary-type current transformers down to 100 amp primary current with high accuracy. The transformer errors are measured precisely, before installation, so that these can be compensated for during meter calibration.

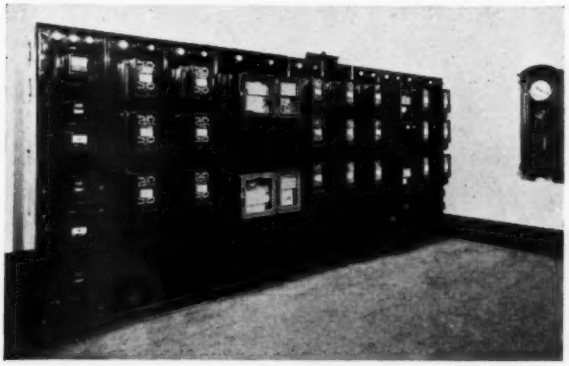
The high cost of the voltage transformers is one deterrent to metering at a high-voltage source, and these transformers are normally used on power consumers' premises only when low-voltage load dispersion would require summation metering or when other practical difficulties intervene.



7 *Meter for recording reactive kilovolt-amperes at the time of maximum kilowatt demand*

Summary

Metering is a specialized subject involving many complex technical problems outside the scope of the present article. Even the apparently simple domestic credit-type meter has not reached finality. At present a national survey is in progress, from which it is hoped to assess the performance of these meters over many years of service life. This may cause further concentration on improvement in design.



8 *C.E.G.B. metering, showing master clock*

There is much interest in the consumer reading his own meter, and an attempt has been made to produce a meter into which the consumer can insert a card, on which the date and reading are stamped. The card can then be sent back to the Area Board at intervals. The idea of putting the card through a calculating machine which automatically ejects an account ready for posting has also had consideration. Another proposal is to place the meter out of doors, but this would preclude the use of prepayment meters.

A further suggestion is to transmit the reading by impulses to a small slave dial fixed outside the house or in such a position that it can be viewed through a window. In the dreams of the future one hears of the meter reader being equipped with a portable two-way radiocommunication set through which he passes the reading to a central depot. He is then told the cash value of the supply, to be collected from the consumer.

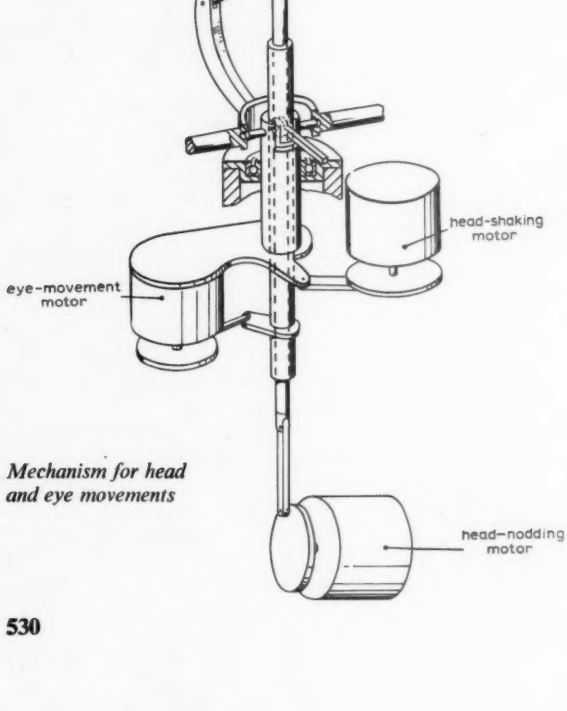
Goethe once said 'Look at the stars but mind the lanes'. This may be appropriate.

Rainbow, a radio-controlled doll

A. M. ATTON, ASSOCIATE MEMBER

DESIGNING and producing the little robot briefly described here constituted an interesting example of the more light-hearted tasks that the electrical engineer may be called on to undertake. Rainbow, as the doll is named, was destined for fame from the outset, having been deliberately created for stardom—in the current show-business fashion.

The requirement was for a remotely controlled doll capable of walking in any direction, moving its arms, nodding, shaking its head and moving its eyes from side to side. Design and construction took two months—about the average time to make a 'star' these days!—and immediately after completion Rainbow was taken on location to feature in a series of films for children. Filming took place in Switzerland in the magnificent mountain country above Lausanne. A number of 'personal' appearances have since been made in this country.



Mechanism for head and eye movements

Motive power

With a weight of about 30lb for a height of 2ft, it will be appreciated that despite his intelligence Rainbow is quite a dense little fellow. It is this combination of weight and small dimensions which resulted in the most difficult aspect of design, namely that of obtaining enough power from the miniature 1watt motors used to drive the limbs. Six of these motors were needed, plus one for steering.

Locomotion was obtained from a larger (1/60b.h.p.) motor driving a pair of wheels of a trolley which serves to propel the doll and also carries the 12Ah 6volt lead/acid accumulator used to energize the motors. The trolley is disguised to resemble a bag or knapsack being carried by the doll, and is fitted with a pair of steerable wheels in addition to the driving wheels.

The body and arms of the doll are of wood, and the legs, feet and head of moulded rubber. The hollow body was carved from a single solid piece of wood, which called for considerable skill on the part of the pattern-maker.

Operation

It was originally intended to provide movements for the legs, arms, head and eyes, but the latter two functions had to be abandoned to enable the doll to be completed within two months, so that the good filming weather of September would not be missed.

Both legs are driven by a single motor via gearing and a pair of opposed cranks. The latter impart a reciprocating motion to extensions of these limbs which project above the hip-joint pivots, thus swinging them backwards and forwards. The feet do not actually touch the ground when in motion, but skim over it.

Each arm is provided with its own motor, and a crank is employed to give a reciprocating motion to each upper arm. The forearm is pivoted at the elbow, and also connected by a jointed linkage, consisting of one straight and one curved link, to a point behind the shoulder pivot of the arm. This linkage is arranged so that the forearm at first follows the upper arm as it swings forward, and then bends at the elbow as the swing continues.

The complete mechanism for the head and eye movements is shown in the diagram, which also makes their operation clear. The nodding and eye movements were not perfected, but the linkages were designed and made, and are built into the doll, but locked.

Control

Remote control by radio is now sufficiently commonplace for this aspect to be conveniently described as conventional. A tuned-reed system is employed, using eight channels. Each channel consists of modulation at audio frequency of a 27 Mc/s crystal-controlled carrier.

Channels 1 and 2 are used for on/off control of the main propulsion and leg-operating motors. Channel 1 starts these motors, which are maintained in operation by a hold-on relay. Operation of channel 2 trips this relay, stopping the motors until channel 1 is operated again.

Channel 3 is used for control of the steering motor via a changeover relay which provides for reversal of the motor. Channels 5 and 7 actuate the left- and right-arm motors, respectively. Channel 4 was allocated to the eye movement, channel 6 to the head-nodding motor, and channel 8 to the head-shaking motor.

Summary

The author used experience gained earlier in designing the electrical circuits of the radio-controlled lawn mower exhibited at the Chelsea Flower Show in May 1959 to overcome the more complex problems presented by the radio-controlled doll.

Considerable assistance was received in this work from Messrs. D. N. Beaney and V. D. Brooker.

SUPER-CRITICAL GENERATING SETS

CONTRACTS valued at about £15 million are to be placed by the Central Electricity Generating Board for the installation of two large super-critical-pressure generating sets at Drakelow C power station, near Burton on Trent. Each set will have an output of 375 MW (500000 h.p.) from a single-shaft machine.

Steam conditions for both machines are 3500 lb/in.^{2} at the turbine stop valve and 1100° F. After partial expansion, the steam will pass through the boiler again and be reheated to 1050° F before re-entering the turbine for expansion to vacuum. These conditions show a marked advance on the present 2300–2400 lb/in.^{2} at 1050° F used for the large generating sets now being built and commissioned.

Although the cost will be slightly higher than that of sub-critical units of similar size, electricity will be generated at a lower cost, which will counterbalance the extra capital charges.

Television at Harwell

CLOSED-CIRCUIT television will enable the inside of the reactor buildings of PLUTO and DIDO to be viewed from outside if it is ever necessary to evacuate the buildings as a result of an accidental release of radioactive materials. PLUTO and DIDO, the most powerful reactors at the Atomic Energy Research Establishment, Harwell, are used to study and make accelerated tests on the effects of irradiation on materials and fuels used in reactors.

Safety devices are already incorporated which will automatically shut them down in any event of malfunctioning. The airtight steel building surrounding each reactor would contain any radioactive material accidentally released, and, although the reactor building would then be evacuated and the reactor could not be run, certain essential operations could be carried out remotely from a heavily shielded emergency control room some distance away. In addition, emergency operations inside the building can be planned and controlled.

The television system can also be used in everyday conditions: a screen in the normal control room inside the reactor building enables the control staff to view and co-ordinate any special work in progress on the reactor top, which is not visible from the control room. There are two cameras for each reactor, but if required for a particular purpose all four could be used with one system.

ELECTRICAL EXPORTS

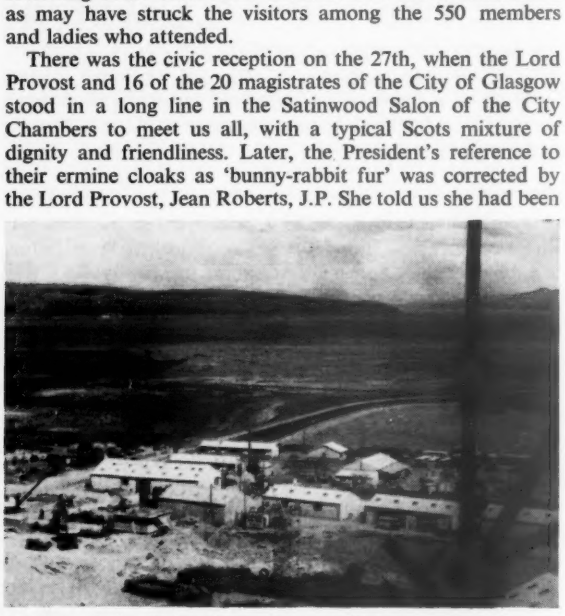
EXPORTS of domestic electrical appliances from the United Kingdom for the first half of 1960 were higher by £2½ million or 17½% than for the same period in 1959, according to provisional estimates made by the British Electrical and Allied Manufacturers' Association. Deliveries of steam and water turbines were up by £1½ million; electricity generating plant exports by £900000; instruments and meters by £800000; and radio and electronic apparatus by £1·75 million. Total electrical and allied exports are put at £150 million for the half-year (some £5 million more than in 1959), of which about 10% was sold to the Common Market countries, about 7% to the European Free Trade Area, and about 60% to Commonwealth countries.

The increase in appliance exports was largely due to additional sales of electric washing machines, which reached a value of £3·7 million compared with £2·5 million a year ago and, including electric dryers separately consigned, totalled £3·9 million for the six months. Over 60% of this total went to European countries, the major customers being Italy and Western Germany. Exports of refrigerators and cooking and heating apparatus were also higher.

CALEDONIA REVISITED

'DRINKA pinta *ilka* day' says the poster on the side of the Glasgow bus, and the visiting Englishman realizes that things are ordered differently over the Border. Writing about The Institution's Summer Meeting in Glasgow from the 27th June to 1st July 1960 provides an opportunity of reviewing some such other differences in the Scottish scene as may have struck the visitors among the 550 members and ladies who attended.

There was the civic reception on the 27th, when the Lord Provost and 16 of the 20 magistrates of the City of Glasgow stood in a long line in the Satinwood Salon of the City Chambers to meet us all, with a typical Scots mixture of dignity and friendliness. Later, the President's reference to their ermine cloaks as 'bunny-rabbit fur' was corrected by the Lord Provost, Jean Roberts, J.P. She told us she had been



A view of the Kyles from the top of the reactor tower at Hunterston

Party with 3300 h.p. a.c. locomotive

chairman of the Electricity Committee of Glasgow Corporation before vesting day, but in face of the long list of Sir Willis Jackson's qualifications in 'Who's Who' she could only say 'What a brain'. She wanted more industry to come to Glasgow.

In these marble halls, the 'vocal music' provided by the Kirkintilloch Junior Choir was touching in its simplicity and freshness.

Lunch with the generators

Then, next morning, the long drive along interminable Loch Lomond ended for one party when their coaches climbed up into the mountains, negotiating hair-pin and -raising bends, to reach the dam at Loch Sloy. The mournful Highland cattle, blasé after so much photographing, stared past the visitors, who themselves gazed into the impenetrable 160 ft depth of the black artificial loch. Following the route of the tunnelled water down to the immaculate ten-year-old power station on the shore of Loch Lomond, we gave a thought to the prisoners of war and displaced persons who had driven the tunnels, at some cost of life, through the bare mountains.

Luncheon at the station was well chosen, generous and highly sociable, the looming background of the four quiet turbo-alternators (this is a peak-load station) seeming no more incongruous than many a modern restaurant interior. The chef, having nowhere to hide, was consulted on some of his efforts and effects.

The standard of the 'Five past eight' show, seen by all the attendance that evening in Glasgow, was further evidence of the difference of these parts. Polished and professional, if rather too loud, it spoke for the Scot's intolerance of the second-rate and shoddy, at any rate in entertainment.

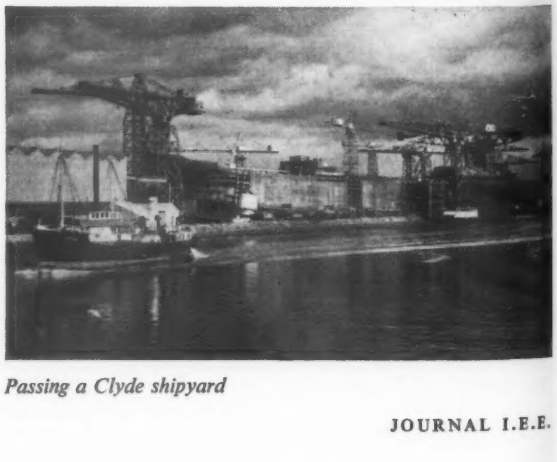
That other city

Some of us took train on Wednesday to that great butt of Glasgow comedians, Edinburgh. Security kept us out of most of a large new electronics factory there, but we were allowed to see a numerical machine-tool-control system actually working on production jobs. They also showed us how they freeze, vibrate, heat, bump and jostle their finished equipment (samples only) to meet various ferocious specifications. At Muirhouse, for their applications laboratory, a baronial hall with variegated chimneys and the arms of the clans on the ceiling has been converted for use by film, photographic and printing units and a Service school. A modern interloper among the coats of arms bore the motto 'vague but keen'.

After lunch, an English coach-driver carried us round the bounds of the city and gave what to English ears seemed a singularly objective, not to say sceptical, commentary on the passing scene and its legends.

Olfactory progress

Among the most famous of the legends of Scotland are the misty tales of Highland burns, smoking peat, and pot stills, complete with incantations, with which the Scot south of the



Passing a Clyde shipyard

Border convinces the Sassenach that the production of Scotch whisky is at the centre of a high mystery. There were full coaches on Thursday morning to test these tales at a distillery at Cambus.

They found that modern process engineering has taken over. There was not a kilt to be seen, no peat, no pot. No one shuddered when the recipe was asked for; no one even claimed special virtue for the Cambus water. All was open, hygienic and efficient, from the grain silos to the crushers, from the crushers to the fermenting vessels, from the vessels to the stills, from the stills to the barrels, from the barrels to the warehouse. Big-brother exciseman's presence was more palpable than evident.

The olfactory progress is from the country smell of maize and barley, the brewery smell of fermentation, the heady alcoholism of the stills, the rare and noble cellar scent of the warehouse, to the frankly chemical aroma of the by-product plant, where solid blocks of carbon dioxide and ammonia are thriftily stored for sale. Nothing is wasted here.

A temple of things of the spirit, with a high priest, archbishop and acolytes, was how Mr. J. R. Rylands described it all in thanking the hosts at luncheon.

At Stirling Castle in the afternoon, the stentorian Scottish guide, though partisan about Bannockburn, whose field he pointed out, and about the English, was as objective about the Castle's legendary history as the Edinburgh coach-driver. 'Lies', he cheerfully shouted. Down the hill, the Provost of Stirling gave us tea in the palatial Municipal Chambers of this town of 30000 people, and told us that the street we had traversed would, when its reconstruction was finished, be the finest in Europe.

At the Institution Dinner-Dance in Glasgow in the evening, a piper drained at a draught a vast dram of whisky; the President asked the City Fathers and industry to lend their aid towards the expansion of the University and the Royal College; Bailie William Brown, senior magistrate, inquired whether the members were going to work for the benefit of mankind or be commercial; Mr. J. A. Aked, Chairman of the Scottish Centre, referred to himself as a Yorkshire export reject; and Lord Strathclyde spoke of the great responsibilities of electrical engineers.

The scene from the roof of a silo at Cambus

Presentations were made to Mr. John de Villiers, retiring after seven years as Honorary Secretary and Treasurer of the Centre, and to the President and Lady Jackson.

A photographic cruise

Friday, 1st July was Clyde cruise day, all day. From Glasgow to the Kyles of Bute and back, the whole party gazed at the shores, dozed in the lounges, photographed everything in sight and listened with difficulty to the imperfectly broadcast but impeccable commentary of Round-Britain-Quiz expert Mr. Jack House. The scenery was beautiful, the food was excellent and the sun shone most of the time.

A supper-dance and cabaret in the evening completed the week in a manner entirely fitting.

To all the individuals, organizations and companies who gave their time, energies and resources to make this Summer Meeting for the visitors so full and pleasurable, grateful acknowledgment is made.

Great interest in the hot forming of thick steel plate in the boiler-drum shop of an engineering works

The pressure pipelines at Loch Sloy

CORRESPONDENCE

INSTITUTION PUBLICATION PROCEDURES

I ASSOCIATE myself with Mr. W. E. Humphrey's remarks in his letter published in the June 1960 *Journal*.

While the *Journal* is an excellent publication, the *Proceedings* as at present published are difficult to index in a simple way for the average reader, and the great bulk of the matter which has to be collected if normal binding of complete volumes is carried out imposes eventually a difficult bookshelf —and sometimes a transport—problem.

Although I possess a complete collection of *Journals* and *Proceedings* for the last 20 years, except for Part B of the *Proceedings* since publication of that division was commenced, I dare say that three-quarters of the contents are of no interest to me—they may be interesting *per se*, but we are all specialists to some degree, and busy men have little time even to read, let alone to digest, all the matter published in the *Proceedings*. There are many other technical publications to be read as well.

I do not really take Part A for reading, but for reference, and I index those papers which I am likely to require. Some of the Part B papers would also be useful to me, but I do not take that Part because of the additional bulk which would be involved.

By all means let every worthy paper be published, but let arrangements be made so that the individual is able to choose to receive only those which he feels he requires. Although this would involve delay if the full discussions were included with all papers, it would be possible to keep sufficiently up to date by reading the *Journal*. Surely a saving, perhaps large, in printing costs would be achieved.

F. J. HALLIGEY, ASSOCIATE MEMBER

Taaibos Power Station
P.O. Coalbrook, Orange Free State
South Africa

8th August 1960

I READ with interest Mr. W. E. Humphrey's letter in the June 1960 *Journal*, p. 368, and the correspondence which followed it in the August 1960 *Journal*, p. 488. The writers set out very clearly and persuasively the advantages which would follow a change in our publication policy, to be based on the provision of 'separates' of all papers instead of their grouping, as at present, in the successive issue of the *Proceedings*.

There are, however, some considerations which have to be weighed in the opposite scale-pan, of which the two most significant are these:

(a) With engineering papers, the discussion often has a greater importance and bearing on the subject-matter of the paper itself than is the case with papers concerned with pure science; the proposals so far made would detach the discussions from the related papers

(b) Introduction of the system proposed would result in a greater net cost of publication, because we should have to forgo the substantial advertising revenue that is received from the present *Proceedings*.

Changes of the kind suggested in this correspondence have been considered by the Papers Committee and the Council on a number of occasions since the recent war, and each time they have come to the conclusion that on balance the present method suits The Institution best.

One piece of corroborative evidence, which seems to have some cogency, is that the average printing order for a monograph is 150 copies to meet the world demand as a 'separate', including some copies to be held in reserve for stock, and 9000 copies for binding and sending to recipients as Part C of the *Proceedings*. This suggests a majority preference for the bound version, rather than the 'separate'.

However, in view of the interest which this correspondence has shown, I am quite sure that the Papers Committee and the Council will wish to look at the matter afresh, and I am therefore asking for this to be done at an early meeting.

O. W. HUMPHREYS, C.B.E., B.SC., VICE-PRESIDENT

Soval, Maxwell Road
Northwood, Middlesex

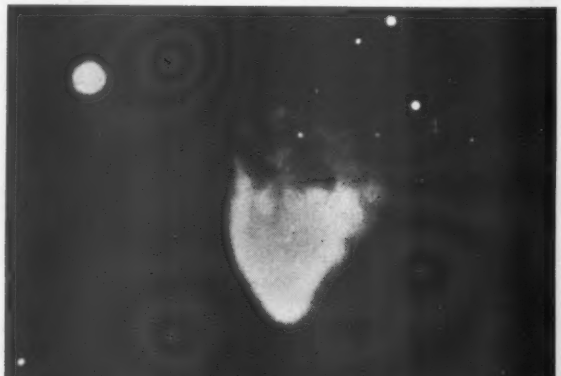
26th August 1960

(Mr. O. W. Humphreys is Chairman of the Papers Committee)

COSMIC ELECTRICAL DISCHARGES
2—SPIRAL STELLAR *NEBULAE*

I RECENTLY called attention[1a] to some of the successful applications of the electrical-discharge theory of astrophysical atmospheric phenomena in the field of radio astronomy, as it is the only theory which affords an explanation for either of the two fundamental requirements of current theories of the origin of cosmic radioemission—magnetic fields and relativistic electrons.

As the value of any scientific theory can best be measured in terms of the successful predictions to which it leads, perhaps you will allow me to refer to one or two of such



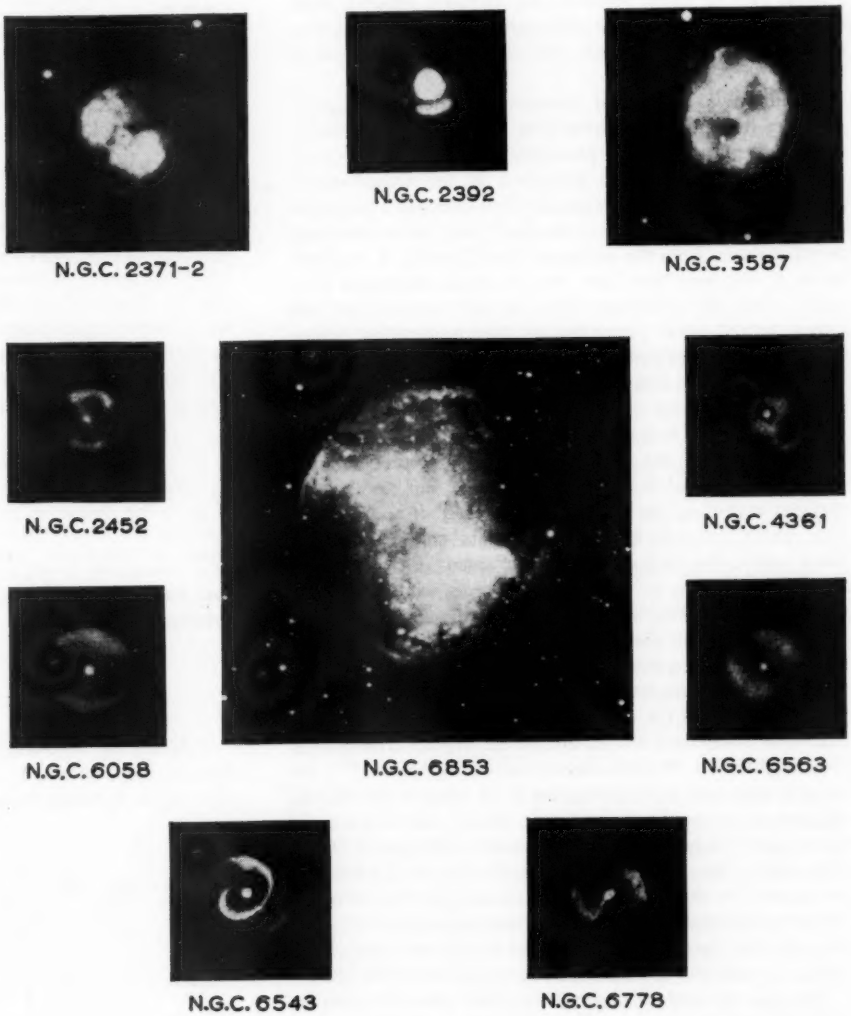
1 *Photograph of Hubble's Variable Nebula, taken at Mount Palomar Observatory in 1949*

recent successes of this theory, particularly as one of the most outstanding and surprising of these predictions was first made in a short contribution to last year's convention on thermonuclear processes.[1b]

In that contribution, and in the fuller accounts subsequently published elsewhere,[1c, d] it was pointed out that the interpretation, on the discharge theory, of Meinel's observation of particles entering the Earth's upper atmosphere at velocities of the order of 3500 km/s during aurorae, led to the surprising conclusion that during these solar atmospheric electrical discharges, which the theory suggests are the cause of magnetic storms and aurorae, the temperatures must reach values of the order of 100000000° K somewhere between the sun and the Earth. Though this seemed to be 'sticking one's neck out' with a vengeance, I could point to the fact that temperatures of the order of 1000000° K had already been observed in the solar corona, and indeed in electrical discharges in the laboratory.[2]

Furthermore, I could point to another example of such a rise in temperature when an electrical discharge is propagated down a similar, but much smaller, atmospheric-density gradient. In the corresponding, but much greater, outbursts in the combination-spectra stars, the spectrum in the early stages contains bright emission lines of hydrogen, helium and the ionized metals, denoting the existence of temperatures of the order of 5000°–10000° K. However, when the discharge reaches the outer regions of the star's atmosphere after 100–200 days, its spectrum shows the lines emitted by iron atoms which have lost nine and on occasion even 13 electrons, showing that the temperatures must have reached values of the order of 1000000° K.

It is now satisfactory to learn that satellite observations of 80000 volt X-rays have been made by U.S. Navy scientists[3] during these solar outbursts, which they point out denote the existence of temperatures of 100000000° K, in agreement with this surprising prediction of the discharge theory.



2 *Photographs of planetary nebulae taken at Lick Observatory by H. D. Curtis*[4]

More recently still, the study of a group of stars led me to the conclusion that stars probably exist which possess two cometary nebulae, similar to the one shown in Fig. 1, which is Hubble's well known Variable Nebula. (This picture has the additional interest that it was the first official photograph taken by Hubble himself on the new 200in. Hale Telescope at Palomar Observatory.) These stars, it seemed, should possess two of these nebulae, diametrically opposite each other, analogous to the two major arms of the spiral nebulae, of which last an explanation was offered in a recent E.R.A. Report.[1e]

Inquiry of a number of astronomical friends brought a reference from Dr. P. W. Merrill of Mount Wilson Observatory to the photographs of planetary nebulae taken by Curtis at Lick Observatory and published in the Observatory's *Publications* in 1918.[4] These photographs included a profusion of just such double nebulae as the theory had led me to expect, as will be seen from the examples shown in Fig. 2. Furthermore, it will been seen that, even in these discharges on a stellar scale, the discharge often adopts a spiral form and also a 'barred-spiral' form, though they more often remain straight. On the galactic scale, the discharges often remain straight for quite a long time before they each turn off into a spiral form, and the final result is the well known 'barred spirals', which are at least as common as the 'normal' spirals.[5]

The theory led not only to this successful prediction as regards the general form of these nebulae, but also to predictions regarding the relative brightnesses of the pairs of lines which occur in many of these stars' spectra—one line being emitted by each of the two discharges—as well as about the gas movements to which the discharges will lead. It was the existence of stellar spectra possessing these pairs of bright lines which led to the prediction that these double stellar nebulae exist. If the two discharges occur in the line of sight, the gas in the nearer discharge will be coming towards us and will therefore emit the violet component of the spectrum line. The violet component should thus be the brighter in most stars.

In a group of 20 such stars observed by Merrill,[6a, b] the violet component was the brighter in 13 stars, in six the two components were about equal, and in only one was the red component the brighter, in good accord with theory. These observations are, on the other hand, the reverse of what is to be expected on the basis of Curtis's own suggestion to explain these double nebulae. He suggested that matter was falling in towards the star from its poles, in which case the nearer nebula would have emitted the red component of the lines.

The gas movements observed in these planetary nebulae had defeated all attempts at their explanation on all the varied hypotheses tried by Campbell and Moore, also at Lick Observatory.[7] The two discharges will each give rise to a jet of gas, which is sometimes straight and sometimes a spiral. On this basis, the observations can be satisfactorily explained. A fuller account of these recent results will be given as an E.R.A. Report, and will, it is hoped, appear in an astronomical journal.

C. E. R. BRUCE, M.A., D.SC., MEMBER

The Electrical Research Association Laboratory
Cleeve Road
Leatherhead, Surrey

18th July 1960

1 BRUCE, C. E. R.: (a) *Journal I.E.E.*, 1958, **4**, p. 669; (b) *Proceedings I.E.E.*, 1959, **106A**, Suppl. 2, p. 44; (c) *Journal of the Franklin Institute*, 1959, **268**, p. 425; (d) *Nature*, 1959, **184**, p. 2004; (e) 'Evolution of extra-galactic nebulae and the origin of metagalactic radio noise', *E.R.A. Report* **Z/T117**, 1958
2 KURCHATOV, I. V.: Moscow, 1956
3 *Journal of the Franklin Institute*, 1960, **269**, p. 78; *Nature*, 1960, **186**, p. 750
4 CURTIS, H. D.: *Lick Observatory Publications*, 1918, **13**, (3), p. 55
5 DE VAUCOULEURS, G.: *Reviews of Modern Physics*, 1958, **30**, p. 926
6 MERRILL, P. W.: (a) *Astrophysical Journal*, 1932, **76**, p. 156; (b) *Astrophysical Journal*, 1933, **78**, p. 87
7 CAMPBELL, W. W., and MOORE, J. H.: *Lick Observatory Publications*, 1918, **13**, (4), p. 75

A GRAPHICAL SOLUTION OF THE KELVIN EQUATION

I PROPOSE to give an extension of the graphical method of determining the current in a circuit having inductance and resistance which is described in the book by F. A. Benson and D. Harrison* on 'Electric-circuit theory.' It is possible to determine graphically the current in a circuit containing capacitance, inductance and resistance, the solution of which was first given by Kelvin.† The equation for the current in such a circuit may be written:

$$L\frac{di}{dt} + Ri + \frac{q}{C} = 0$$

If Q_0 is the charge on each plate of the capacitor before the circuit is closed and $\int_0^t i\,dt$ the quantity that has flowed since the discharge began, $q = \int_0^t i\,dt - Q_0$ and the equation becomes:

$$L\frac{di}{dt} + Ri = \frac{Q_0 - \int_0^t i\,dt}{C}$$

If L/R is the time-constant τ and V_0 is the initial voltage between the terminals of the capacitor, $Q_0 = CV_0$. Let $I_0 = V_0/R$. Inserting τ and dividing by L:

$$\frac{di}{dt} = \frac{Q_0 - \int_0^t i\delta t}{CL} - \frac{i}{\tau} = \frac{I_0 - \frac{\int_0^t i\delta t}{CR}}{\tau} - \frac{i}{\tau}$$

Let $$i' = I_0 - \frac{1}{CR}\int_0^t i\delta t$$

Then $$\frac{di}{dt} = -\frac{i - i'}{\tau}\frac{di'}{dt} = -\frac{i}{CR}$$

The initial conditions are $i = 0$, $i' = I_0$ at $t = 0$. Construct graphs by plotting i from $t = 0$ and i' from $t = \tau$ (Fig. 1).

A corresponds to i' at $t = 0$. Join OA. Its slope is $I_0/\tau = (di/dt)_{t=0}$. Let the integration interval be δt and assume $\delta t = CR$. Then the point P_1 gives i at δt.

Now $$\frac{di'}{dt} = -\frac{i}{CR}$$

* Edward Arnold, 1959
† MARCHANT, E. W.: 'High-frequency currents', *Journal I.E.E.*, 1927, 65, p. 977

Evaluate i at the mid-point of the interval being considered, and let this be i_1.

Plot Q_1, at $\tau + \delta t$, $= I_0 - i_1$, to give i' at $t = \delta t$.

$$\text{Slope of } Q_1P_1 = \frac{(i' - i)_{t=\delta t}}{\tau} = \left(\frac{di}{dt}\right)_{t=\delta t}$$

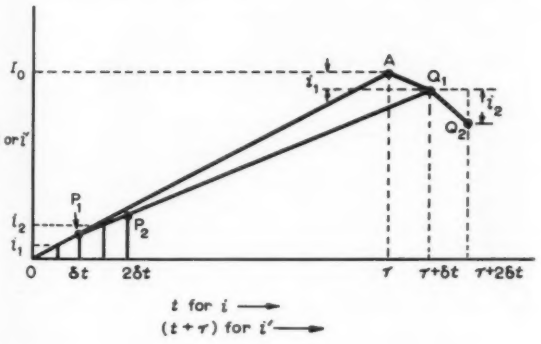
Then P_2 gives i at $t = 2\delta t$.

Plot Q_2 at $\tau + 2\delta t$, $= I_0 - i_1 - i_2$, to give i' at $t = 2\delta t$, and so on.

A numerical example will make the method clearer. Take first an oscillatory circuit in which $R < 2L$. Let $L = 1$ henry, $R = 0{\cdot}2$ ohm, $C = 1$ farad and $V_0 = 10$ volts: $CR = 0{\cdot}2$sec. It will be convenient when drawing the curve to take $\delta t = 0{\cdot}2$sec, which is equal to CR as assumed above. The resultant curve is shown in Fig. 2. After about 1·6sec, the current has increased to about 9amp and the value of i' is also equal to 9amp, so that $di/dt = 0$, and then becomes negative, until after 3·15sec $i = 0$. i' is proportional to the voltage on the capacitor and may be plotted at the same time.

If $R \geqslant 2L$ the circuit becomes non-oscillatory. In Fig. 3, $R = 2$ ohms, the other constants in the circuit are the same as in Fig. 2, $\tau = 0{\cdot}5$sec and $CR = 2$sec. If the time interval for integration is the same fraction of the time-constant, $\delta t = 0{\cdot}02$sec and $\delta t/CR = 1/100$. In plotting the curve, $\delta t = 0{\cdot}1$sec and $\delta t/CR = 1/20$.

The initial slope of the current curve V_0/L is the same as in Fig. 2, but $\left(\int_0^t i\delta t\right)\Big/CR$ is one-twentieth of the average value of i during the first time interval, and i' decreases much more slowly and i never becomes negative. The current curve



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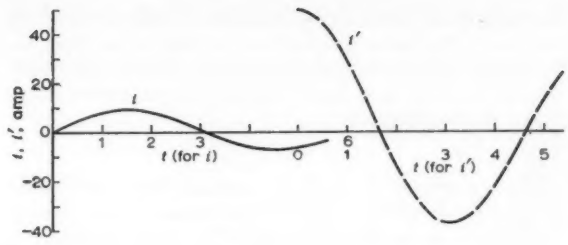
in Fig. 3 has been drawn by the same construction as in Fig. 2. If the resistance is increased to, say, 20 ohms, the time-constant is now 0·05sec and $CR = 20$sec, so that, if δt is the same fraction of the time-constant, $\left(\int_0^t i\delta t\right)\Big/CR$ is one-thousandth of the average value of the current during the integration interval, and di/dt decreases still more slowly, though the maximum value of the current is a larger fraction of V_0/R than for the smaller resistance.

The advantage of the graphical method is that it shows *why* the current curve in an LCR circuit changes from an



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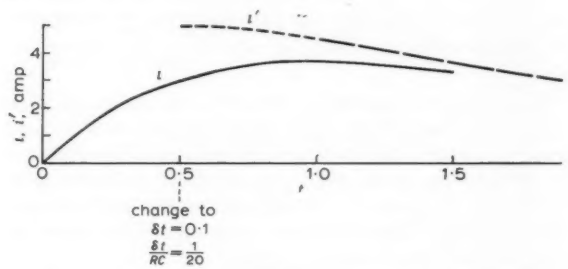


oscillatory to a non-oscillatory form as the resistance increases.

I am greatly indebted to Dr. J. Brown of University College London for his suggestion of introducing i' in the above analysis and for the method of plotting the curves.

E. W. MARCHANT, D.SC., F.C.G.I.,
PAST-PRESIDENT, HONORARY MEMBER

Brook Farm, Grendon
29th July 1960 Atherstone, Warwickshire

WESTERN EUROPEAN STANDARDS

REPRESENTATIVES of the British Electrical and Allied Manufacturers' Association serving on international standards committees have been urged by their Council to work actively towards aligning electrical engineering standards among Western European countries.

During the last two years, the European Economic Community has been striving to achieve common standards throughout the 'Six' countries. An important result of a recent meeting in Zürich of the Western European national standards organizations was that the six Common Market countries expressed their willingness to extend the collaboration so that the 'Six' and the 'Seven' (E.F.T.A.) countries will in future co-operate on an equal footing.

The 13 countries will now work as equal partners towards the alignment of Western European standards and the maximum development of international standards through the I.S.O., the I.E.C. and the C.E.E.

The B.E.A.M.A. Council stress that the policy of the industry should be governed by the will to reach agreement on such standards and the willingness to effect reasonable compromise with other countries taking part, e.g. on performance and dimensions.

Thermistors

This short article is based on a Measurement and Control Section paper (3176) entitled 'Thermistors, their theory, manufacture and application' by R. W. A. Scarr, B.Sc.(Eng.), Ph.D., Associate Member, and R. A. Setterington, B.Sc. The paper was published individually in January 1960 and will be republished in Part B of the Proceedings. It was read at Savoy Place on the 5th April 1960 before the Measurement and Control Section (see p. 566). The authors are with Standard Telephones and Cables Ltd.*

THE result of sintering a mixture of the oxides of manganese, nickel and copper is a material with a large negative temperature coefficient of resistance. Two-terminal circuit-elements made from these or other oxides or from sulphides are known as 'thermistors' or thermally sensitive resistors. Most thermistors have a resistance/temperature law approximately of the form:

$$R = R_\infty \exp(B/T)$$

where R is the resistance at T degrees Kelvin, B is a constant temperature for a given material, and R_∞ is a constant resistance depending on the material and geometry of the thermistor.

Departures from this law are often significant over a range of temperatures in excess of about 20°–50°C, and then an empirical equation must be assumed or the characteristic must be measured.

Conduction in a thermistor is electronic as opposed to ionic, and, provided that the temperature of the element is constant, current is proportional to applied voltage. The theory of conduction in thermistor materials, most of which may be regarded as polycrystalline semiconductors, is not nearly as well understood as it is in a single crystal of a material such as germanium. It is believed that thermistors owe their properties to physical rather than chemical imperfections and that the behaviour of the physical imperfections is governed by oxygen content.

Thus the high order of chemical purity needed for a transistor is not essential for a thermistor, but the dependence of the characteristic on oxygen content means that, for the highest stability, the thermistor must be enclosed in a hermetically sealed envelope. This container can consist of a solid glass bead or a glass bulb with an inert filling (see Fig. 1).

The construction of a thermistor is closely allied to its application, and applications may be divided into four broad categories:

(1) measurement of temperature, including temperature control and compensation

(2) measurement of power

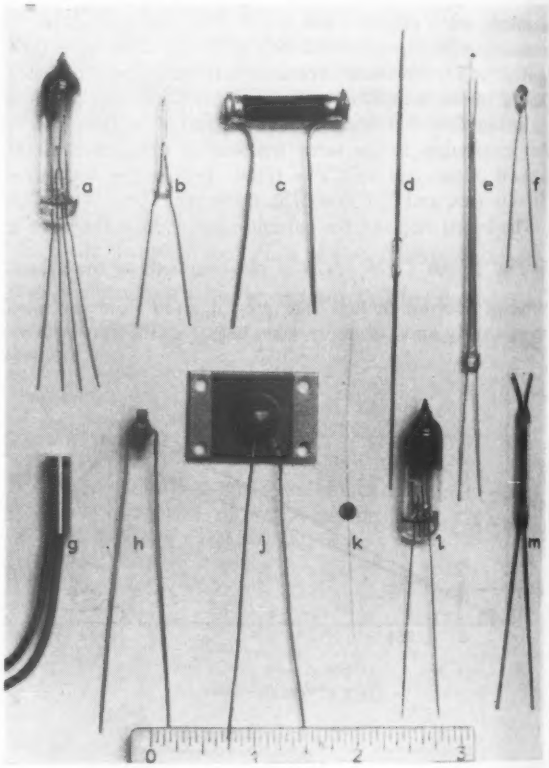
(3) automatically or remotely controlled variable resistors

(4) non-linear circuit-elements for surge suppression, delay and thermal oscillation.

* This article and those following are based on, and written by the authors of, current Institution papers. The authors have been asked to make these articles, so far as possible, interesting and of appeal to electrical engineers who have no specialized knowledge of the topics, and the content of the articles is not necessarily confined to the subject-matter of the original papers

Temperature measurement

A glass-bead thermistor is commonly used, and with a temperature coefficient of −3% to −5% per deg C it gives excellent discrimination, and one may expect a stability of



1 *Types of thermistor*

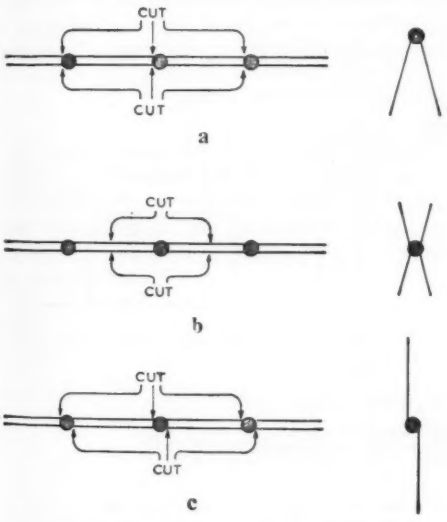
- a Indirectly heated bead for remotely controlled variable resistor, e.g. in automatic gain control
- b Directly heated bead for time delay, a.g.c. circuits or current-surge suppression
- c Rod type for current-surge suppression
- d Directly heated bead for microwave power measurement
- e Directly heated bead, probe-type thermometer
- f Directly heated bead with a wide range of applications
- g f mounted in metal case
- h Disc type for temperature measurement, control and compensation (up to 120°C)
- j Disc type as h, mounted for surface measurements
- k Directly heated bead, skin thermometer
- l Directly heated bead, a more power-sensitive version of b
- m Directly heated bead for anemometry and thermal-conductivity measurements, e.g. vapour-phase chromatography

between 2×10^{-4} and 2×10^{-1} °C, depending on the period of the observation and the temperature range of the experiment. It is usual to connect the thermistor as one arm of a Wheatstone bridge or, when a temperature difference is required, to have a matched pair of thermistors, one in each ratio arm of the bridge.

Bead thermistors are made by placing drops of the unfired thermistor material, which is in the form of a slurry mixed with an organic binder, on two parallel platinum wires (Fig. 2). After drying, the beads are sintered and the wires cut to give the termination consistent with a particular encapsulation (e.g. solid glass or a glass bulb).

In the temperature compensation of, for example, the resistance of a focusing coil of a cathode-ray tube, the power in the circuit may result in a bead thermistor being overrun, and a more massive block of disc-shaped thermistor material is better. A shaping network consisting of series and/or parallel resistors can be combined with the thermistor to give a wide variety of resistance/temperature characteristics.

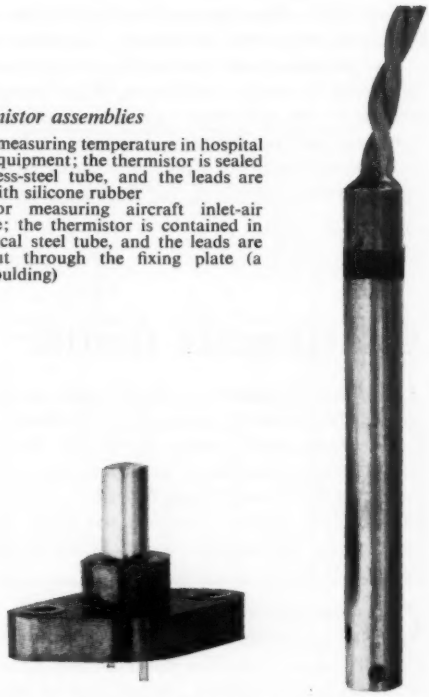
Disc thermistors are made by compressing the powdered oxides in a die, applying a metallic paste to form the contacts, and firing in carefully controlled conditions. By adjusting the contact area, it is possible to make these thermistors to a closer tolerance than can be achieved by the other methods. When leads have been soldered to the disc, the thermistor is coated with a protective paint. Fig. 3 shows two specialized thermistor assemblies for temperature measurement.



2 *Manufacture and cutting of beads for various types of assembly*

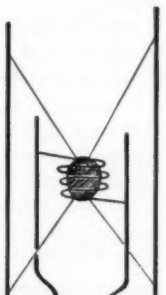
Power measurement

To obtain high power-sensitivity, a thermistor in a vacuum- or gas-filled glass bulb is recommended. The resistance of the thermistor is substantially constant over a range from a low frequency related to the inverse of its thermal time-constant to a high frequency of tens or hundreds of megacycles per second which depends on lead inductance and other constructional parameters. However, this does not preclude the use of the thermistor at much higher frequencies, provided that it is possible to match the thermistor's resistance to the source of power, and special thermistors are made for operation up to about 10Gc/s.



3 *Two thermistor assemblies*

(right) For measuring temperature in hospital sterilizing equipment; the thermistor is sealed in a stainless-steel tube, and the leads are insulated with silicone rubber
(below) For measuring aircraft inlet-air temperature; the thermistor is contained in the cylindrical steel tube, and the leads are brought out through the fixing plate (a Bakelite moulding)



4 *Construction of indirectly heated thermistor*

The thermistor as a variable resistor

The thermistor is widely employed as a variable resistor in a.g.c. systems, for example to stabilize the output of an oscillator or an amplifier or a voltage regulator. Very often the thermistor is associated with the feedback loop. An indirectly heated thermistor (Fig. 4) gives a good isolation between the control signal and the signal to be controlled,

and a glass-bulb construction gives the power sensitivity that is normally desirable for the application.

Non-linear circuits

At low frequencies, the temperature of the thermistor will follow, with a time-lag, the variations in the voltage applied to it, and for a small increment its behaviour is analogous to that of an inductance shunted by a resistance, both being in series with a negative resistance. When suitably biased and combined with an element having a capacitive reactance, the thermistor will oscillate at a frequency dependent mainly on its mass and shape but typically of the order 0·01–10c/s.

In transient operation, the thermistor will, because of its finite heating time, suppress a surge or provide a delay. For example, it reduces the switch-on surge when it is connected in series with valve-heaters or a projection lamp. The ability of a thermistor to oscillate and suppress surges is entirely due to its having a relatively large negative temperature coefficient.

Rod thermistors are suitable for surge suppression and are made in a similar way to disc thermistors, except that they are extruded from a die before firing.

This outline has indicated only a few of the thermistor's possible applications, and there is little doubt that the thermistor is one of the most versatile of components, able in many cases to compete on equal terms with other com ponents of more specialized application. 621.316.825.2

Continuous denier recorder

A brief article based on a Measurement and Control Section paper (3256) entitled 'An automatic continuous denier recorder for synthetic textile yarns' by C. D. Rutter, B.Sc.(Eng.), R. D. Wright, B.Sc.(Eng.), Associate Member, R. N. Aldrich-Smith, M.Sc., F.Inst.P., and E. J. R. Hewitt, M.A., Associate Member. The paper is published this month in Part B of the Proceedings. The authors are with British Nylon Spinners Ltd.

Continuous-filament yarns of synthetic fibres such as nylon are produced by extruding molten polymer through a small hole in a die. The material cools in air, solidifies and is wound up on bobbins. Factors such as extrusion rate and wind-up speed cause undesirable variations in the thickness of the finished yarn, and it is essential to make measurements of yarn thickness at regular intervals, or preferably continuously.

The thickness of a yarn is specified, for a range of materials including nylon, in terms of denier, which is the weight in grammes of a 9000m length of yarn. To monitor the denier, it is necessary to measure the mass per unit length of the yarn, and the standard method is to reel off a measured length, usually 90m, weigh it and convert this to denier. This is a time-consuming operation and, since it determines the mean denier over a fairly long length of yarn, ignoring short-term variations, is of little use for quality control.

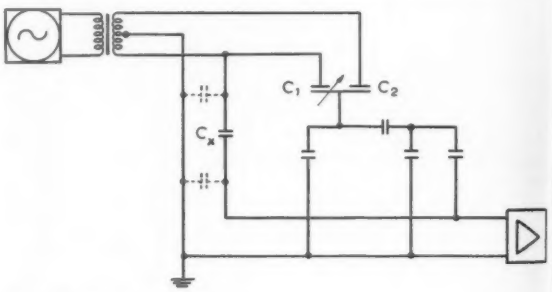
Capacitance change

One method of monitoring a moving thread line instantaneously is to make use of the increase in capacitance between two parallel-plate electrodes caused by the insertion of yarn between them. This increase in capacitance varies directly with the square of the diameter of the yarn and inversely with the square of the separation of the capacitor plates. The relationship is linear with denier to within ±1%, provided that the yarn diameter is less than one-third the gap of the capacitor.

The diameter of a 15 denier monofilament stocking yarn is 1·7 mils, and this will produce in a typical capacitor a change in capacitance of 10^{-3}pF. The standing capacitance of this capacitor is 1pF, so to measure the yarn to ±1% will require a stability of 10 parts in 10^6 in standing capacitance. This stability is not possible for an exposed capacitor in factory conditions.

Vibrating yarn

The present instrument has been designed to overcome this stability problem by measuring only the difference in capacitance due to the yarn and ignoring changes in standing capacitance of the head. To do this, the yarn is vibrated in and out of the gap—for convenience, at 50c/s.



1 *The basic bridge circuit*
C_x = yarn-measuring capacitor
C_1, C_2 = variable balance capacitors

The capacitance between the two electrodes is therefore varying at the frequency of the vibrating yarn, and a variable capacitor is switched into a bridge circuit in phase with the yarn and used to balance this change in capacitance.

The output from the bridge is amplified and used to drive a motor which rebalances the bridge by adjusting the variable capacitor. The motor also drives a pen recorder.

Heads fixed at several positions are required to be switched to a central measuring instrument, and it is therefore necessary

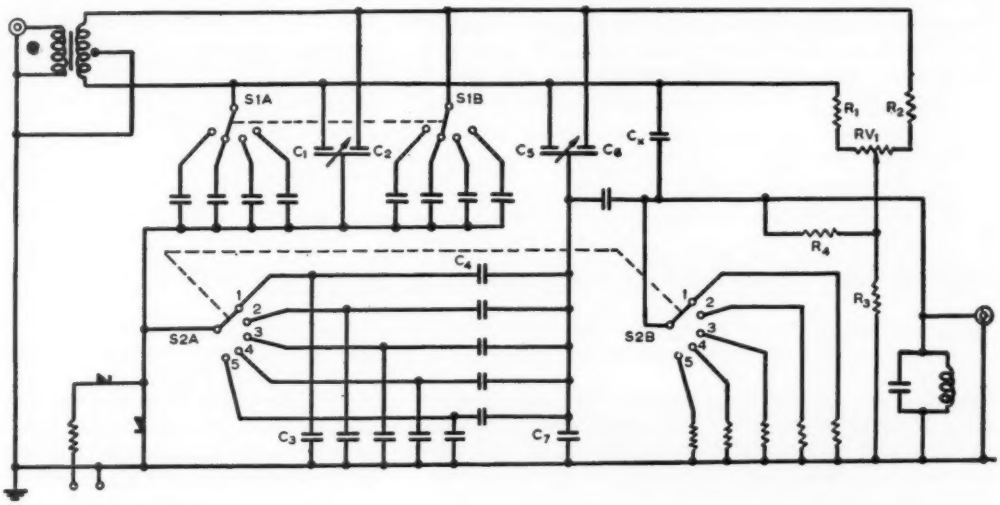
to use a measuring circuit capable of measuring at the end of a cable about 20ft long.

Bridge circuit

The bridge circuit shown in Fig. 1 uses closely coupled inductive arms, and the balance-point is not affected by the stray earth capacitance of the leads to the head. One lead capacitance merely puts a load across the amplifier, and the other puts a load on the supply. Both have the same over-all effect of reducing the output when the bridge is off balance, and neither affects the balance-point. The bridge circuit also has the advantages that the bridge ratio can be altered, so providing several ranges, and the balance capacitor can be of a convenient size.

A frequency of 1 Mc/s has been chosen as the highest, for easy construction. The higher the frequency, the less the dielectric constant of the nylon increases owing to absorbed water. Future instruments could well operate at a higher frequency.

Fig. 2 shows the actual bridge circuit used, which includes static balance networks and a variable capacitor which is switched in and out in synchronism with the yarn.



2 *A working circuit*
C_1, C_2 balance the effect of the vibrating yarn in C^x

The unbalance signal from the bridge due to the yarn or the chopped balance capacitor consists of 1 Mc/s bursts 50 times a second. After amplification, they are detected in a phase-sensitive rectifier and produce 50c/s signals. These are further amplified to drive the balancing motor, which is a normal 2-phase servomotor. 621.317.39

Resistance of sheet insulation to surface discharges

A brief article based on a Measurement and Control Section paper (3250) with the above title by J. H. Mason, Ph.D., Associate Member. The paper was published individually in April 1960 and will be republished in Part A of the Proceedings. It was read at the Ordinary Meeting on the 12th May 1960 at Savoy Place (see p. 562). The author was formerly with the British Electrical and Allied Industries Research Association and is now at the A.E.I. Research Laboratories at Harlow.

ALTHOUGH it is widely recognized that many failures in electrical equipment are caused by discharges in cavities or over the surface of insulation, it is not always practicable to design equipment which is discharge-free. Hence standard tests are required for predicting the life of insulation and for assessing the relative resistance of materials to discharges in service conditions.

Short-duration electric-strength tests do not give this information, because failures at high stresses are caused by thermal instability or rapid penetration by discharge channels due to intense stress at their point of impact on the insulation, whereas, in service, failure by discharges is usually caused by erosion or chemical degradation.

Evidence of chemical damage after times too short to cause failure (e.g. increased acidity and dielectric loss) is difficult

to interpret, and there seems to be no alternative to life-testing materials in conditions simulating those in service. For general purposes, it is preferable to assess resistance to surface discharges, rather than to internal discharges which are usually less deleterious. Moreover, the inception voltage and magnitude of surface discharges are determined primarily by the thickness and permittivity of the insulation, whereas the behaviour of internal discharges is largely determined by the dimensions of the cavity.

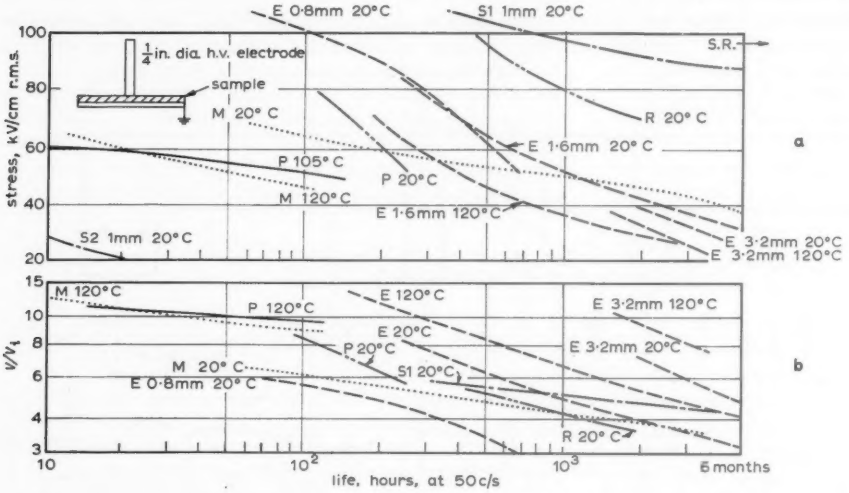
The paper shows that 'time to breakdown' tests using simple rod and plate electrodes provide a reproducible classification for the discharge resistance of sheet and laminated insulating materials and for thin polymer films. The relative discharge resistance of materials is best assessed from curves showing the variation of life with stress, for samples of similar thickness, as in Fig. 1a.

Provided that the formation of semiconducting surface films is avoided by passing dry air over the samples, tests at 20° C can usually be accelerated by increasing the frequency to 500c/s or 1kc/s, without affecting the life in cycles. At higher temperatures, frequency acceleration should be used with caution because, in many materials, the higher discharge frequency causes rapid failure by thermal instability at a much lower stress than at 50c/s.

Laminates and sheet insulation

Fig. 1a shows that silicone-rubber and certain silicone–glass laminates have much greater discharge resistance than other organic materials. Some silicone resins do not bond well to glass fabric, and in this case discharges cause rapid failure at low stress, as shown for laminate S2.

At 20° C, polymethylmethacrylate (p.m.m.) and rigid p.v.c. show discharge resistance similar to that of epoxy–glass laminates, but p.v.c. degrades more rapidly at higher temperatures. Fig. 1a shows that increased temperature also severely reduces the discharge resistance of melamine-bonded glass and phenolic-bonded paper laminates.



1 *The effect of discharges on the life of sheet insulation*

a showing dependence on stress

b showing dependence on the ratio of the applied voltage V to the discharge-inception voltage V_i

Samples (1·5mm thick except where otherwise stated) were tested in dry air between rod and plane electrodes

S1, S2 silicone-, E epoxy-, and M melamine-impregnated glass laminates; R linear polythene; P phenolic-bonded paper laminate; S.R. silicone rubber

An approximately linear relationship is often found between $\log_e(ft)$ and $\log_e(V/V_i)$ as shown in Fig. 1b, where f is the test frequency, t the life in seconds, V the test voltage, and V_i the discharge-inception voltage. This presentation, however, is not suitable for comparing materials, since a cursory inspection suggests that the discharge resistance of many materials increases with temperature.

Tests were also made with specimens bent over a cylindrical low-voltage electrode. Table 1 shows that the life of many laminates is greatly reduced if the surface exposed to discharges is also subjected to tensional strain, but compressive strain on this surface has no significant effect.

Table 1. The effect of mechanical strain on the discharge resistance of laminates at 20° C

material		thickness	stress	mean life at 50 c/s		
				no mechanical strain	subjected to a strain of	
resin	fabric				0·25%	0·55%
		mm	kV/cm (r.m.s.)	hours	hours	hours
silicone	glass	1·6	62	$>10^4$	265	—
epoxy	glass	1·5	62	600 ± 70	500 ± 80	—
		3·0	40	950 ± 100	—	500 ± 150
polyester	glass	1·7	65	220 ± 20	100 ± 80	—
melamine	glass	1·6	65	105 ± 10	65	—
phenolic	nylon	3·2	45	>400	—	42
phenolic	paper	3·3	45	400 ± 50	—	18 ± 2
		1·6	65	160 ± 25	—	95 ± 10

Thin polymer films

A cylindrical low-voltage electrode is recommended for testing thin films, as it is difficult to prevent them wrinkling on

a flat surface. It is also necessary to avoid mechanical damage under the weight of the high-voltage rod electrodes, so these are clamped 75 ± 50 microns above the film. The presence of this gap greatly reduces the scatter in results on thin and soft materials, but does not significantly affect either the inception voltage or the magnitude of the discharges, or the relative discharge resistance of materials.

The relative times for materials to fail vary with the applied stress, the ambient temperature, and the thickness of the material, but the following classification in order of decreasing resistance to discharges is indicated at 20° C:

Polythene: the lower the melt index, the greater the discharge resistance
Polycarbonate (Makrafol)
Polyethylene terephthalate: Melinex is more resistant than Mylar
Cellulose acetate
Polytetrafluorethylene cast from dispersion
Polytetrafluorethylene veneered from sintered block.

The discharge resistance of Melinex is little affected by temperature, but the life of the other materials is between five and 20 times shorter at their maximum rated temperature than at 20° C.

The life of polythene films subjected to unidirectional voltage pulses is considerably greater at a given stress than at the same alternating peak stress. It is also shown that the discharge resistance is greater with positive than with negative pulses applied to the rod electrode. 621.317.333.6 : 621.387

Measurement of depth of surface hardness

A brief article based on a Measurement and Control Section monograph (372) entitled 'Investigation of an electrical non-destructive method of measuring the depth of surface hardness in flame-hardened steels' by J. A. Betts, B.Sc., Ph.D., and J. P. Newsome, M.Sc., Associate Member. The monograph was published individually in April 1960 and is republished this month in Part C of the Proceedings. The authors are in the Department of Electrical Engineering, University of Nottingham.

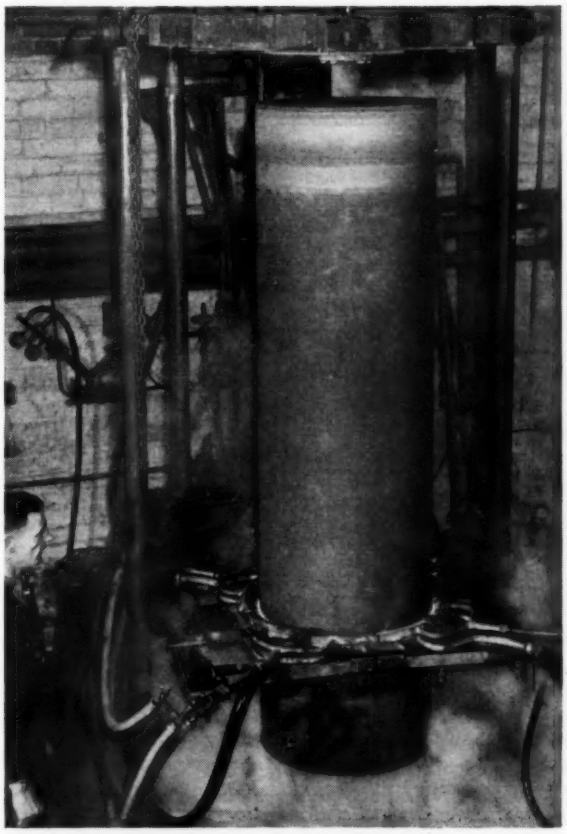
A flame-hardening process in operation is shown in Fig. 1. The cylinder, which is being uniformly surface-hardened, is moved slowly through a radial gas-burner and adjacent water-quench. It is doubtful if existing electrical non-destructive testing techniques are capable of directly measuring the depth of surface hardness in flame-hardened steels independently of such variables as pre-quench temperature and steel composition. Fig. 2 shows the variation of mechanical degree of hardness with depth below the steel surface for a flame-hardened steel; the transition between the hardened and the unhardened region is seen to be quite definite.

The paper gives an account of exploratory investigations of two possible electrical methods of measuring the depth of surface hardness.

D.C. method

In the first, direct current was introduced into the steel through point electrodes placed on the hardened surface. The basis of the method was to derive the depth of surface hardness in terms of the surface-potential distribution, which was measured with further sets of point electrodes. The surface-probe technique is widely used for the measurement of the resistivity of semiconductor materials and in geophysical surveys.

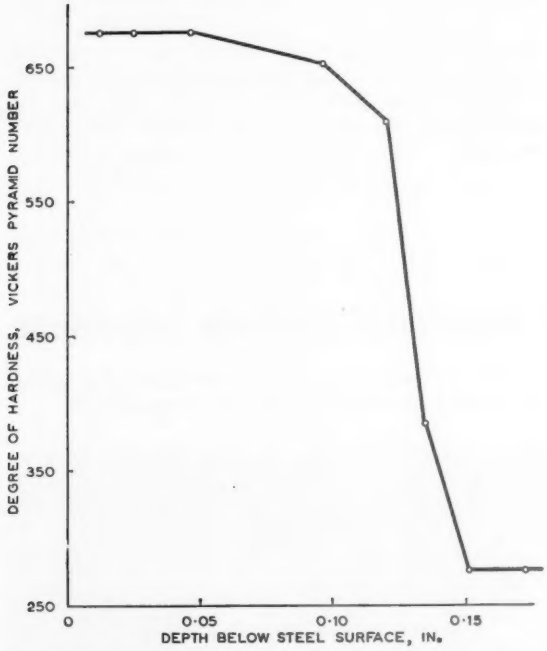
Little success was achieved with this method. The difficulties were found to be mainly due to the high accuracy required in the measurement of voltage and probe spacing; a complete analytical solution to the problem would require a knowledge of the variation of resistivity within the hardened layer.



1 *A flame-hardening process in operation*

High-frequency a.c. method

The second method, with which the paper is largely concerned, makes use of a coil closely coupled to the steel test surface by means of a ferrite cup-core and carrying a sinusoidal alternating current of frequency 8–10kc/s. This assembly, which is shown in Fig. 3, is termed a probe unit. In



2 *Variation of degree of hardness with depth below steel surface*

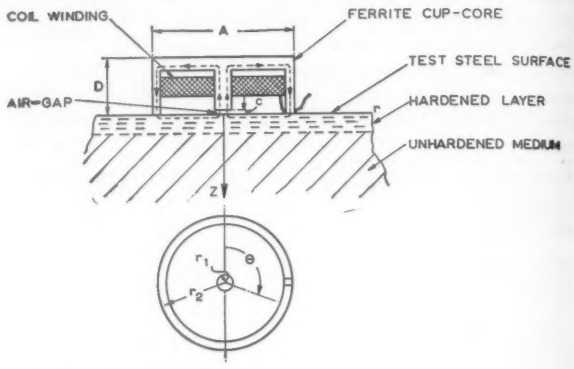
using this range of frequency, the significant depth of flux penetration in the steel is much less than the depth of the hardened layer, which in this work lay in the range 0·05–0·02in.

When a heated steel surface is quenched, the resistivity and permeability of the surface layer are a function of the pre-quenching surface temperature and the severity of quench employed. It is argued that, for a given gas-burner configuration and quench procedure, the resulting depth of surface hardness in a given process will depend on the speed of traverse of the burners over the surface; thus the lower the speed of the burners, the higher will be the pre-quenching surface temperature and the greater the depth of surface hardness.

The depth of the hardened layer is dependent on the pre-quenching surface temperature, so that a method of measuring the surface values of resistivity and permeability would be one of measuring the depth of the hardened layer. Such a technique would be comparative for a given test-piece and would assume a consistent quenching procedure and fixed gas-burner configuration.

Relationship between conductance and frequency

It has been found that a linear relationship exists between the component of conductance of the coil admittance representing the power loss in the test steel with which the ferrite

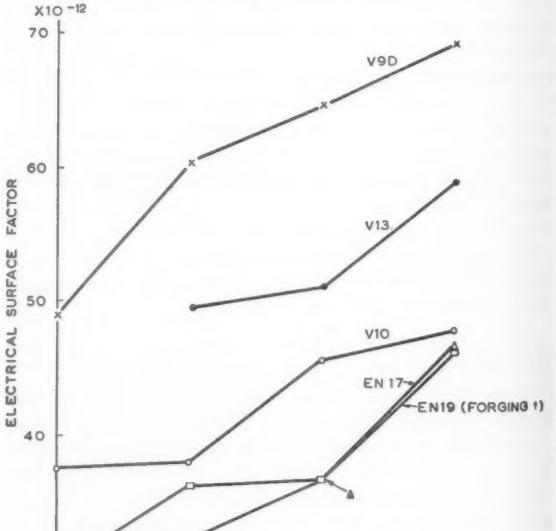


3 *Details of probe unit*
– – – magnetic-flux path

core is in contact and (frequency)$^{-1/2}$. This relationship, which is derived theoretically in the paper, is expressed by the equation:

$$G_m = \frac{b}{\sqrt{(\mu\rho)}} \frac{1}{\sqrt{f}} + h \quad . \quad . \quad . \quad . \quad . \quad (1)$$

where b and h are constants determined by the geometry of the ferrite core, the number of turns on the coil winding and the total flux passing through the coil. The slope of the line



4 *Variation of electrical surface factor with depth of hardened layer for several types of steel*

is $b/\sqrt{(\mu\rho)}$, where μ and ρ are respectively the permeability and resistivity of the test-steel surface.

The ratio of the product $\mu\rho$ obtained from eqn. (1) (which is termed the electrical surface factor) to the product $\mu\rho$ obtained from static-flux measurements was found to be constant for a given size of ferrite core. It is concluded that, in measuring the electrical surface factor of a hardened steel surface, a quantity is being measured which is related to the depth of the hardened layer.

Fig. 4 shows the variation of electrical surface factor with depth of the hardened layer for a number of flame-hardened steel surfaces.

The effect of air-gap between the ferrite core and the test-steel surface is important. The test surface must be prepared so that, over the area carrying the ferrite core, the surface is flat within $\pm 0{\cdot}001$ in.

Extension to curved surfaces

For further development of this method, it will be necessary to design probes which will deal with curved hardened surfaces such as gear teeth. A study of the variation of resistivity and permeability with pre-quenching temperature and severity of quench at and below the surface of a surface-hardened steel is necessary, as a possible ambiguity in the method may arise through the electrical surface factor having the same value for two different depths of surface hardness.

620.179.14; 14: 669.18

Sound diffusion in broadcasting studios

A brief résumé of an Electronics and Communications Section paper (3272) entitled 'Diffusion of sound in small rooms' by K. E. Randall, Graduate, and F. L. Ward, B.Sc., A.Inst.P., Associate Member. The paper is published this month in Part B of the Proceedings. The authors are in the Engineering Research Department, British Broadcasting Corporation.

From the point of view of electrical engineering, the sound chain in a radio or television system might be considered to begin with the microphone and end with the listener's loudspeaker. In practice, however, it includes the rooms at both ends, since its performance is influenced by the acoustic conditions in both the studio and the listener's room and also indirectly by the acoustic conditions prevailing in any control room where quality checking may take place.

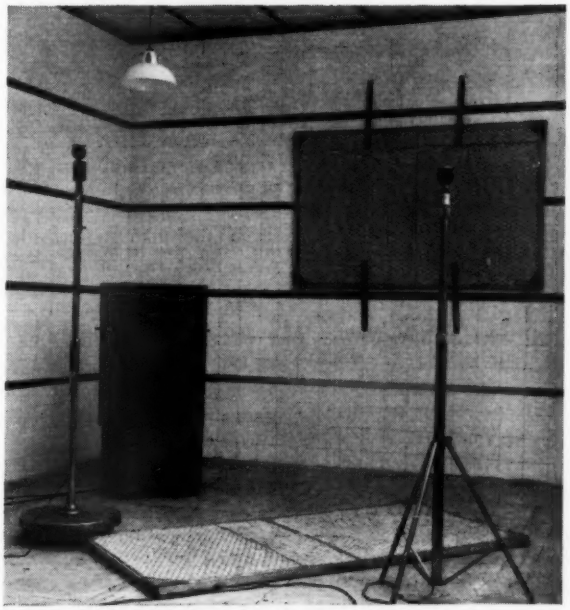
Reverberation time

A multiplicity of factors may affect the acoustical environment of the microphone, the most important undoubtedly being the reverberation time. The control of reverberation throughout the audio spectrum receives a great deal of attention from the studio designers and a certain amount from the operational users of a studio.

Permanent control of reverberation time is achieved by a proper selection of sound-absorbing materials. Apart from absorption occurring in the structure of the building, some takes place in the furniture, carpets and other objects necessary to meet the operational needs of the studio; the remainder is specially provided in order to attain the required reverberation times in different parts of the audio spectrum.

Reverberation room

The techniques of calculating reverberation time are well tried. The formulae used are based on the assumption that the sound field in the room is well diffused, and in these circumstances they are fairly reliable. The most accurate values of absorption coefficients for calculation are normally obtained by measuring the change in reverberation time of an empty room when samples of a given material are introduced into it.

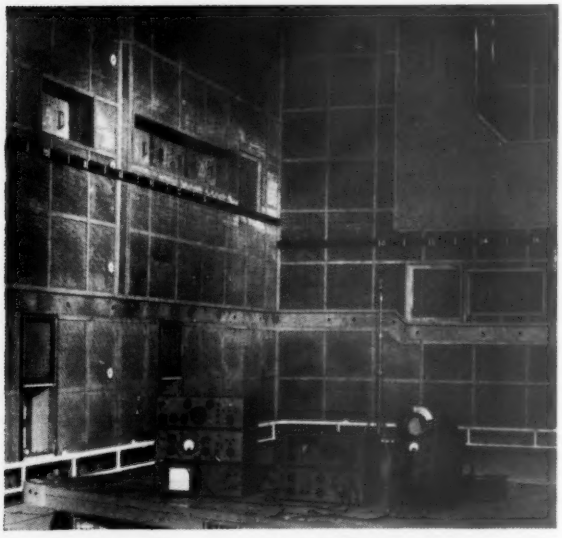


1 *Sound absorbers in a reverberation room*

The same formulae, with the same implicit conditions, are used in this so-called reverberation room as in the studio, thus providing the link between the performance of the sample in the laboratory and in the final studio. The extent to which the sound field is diffused thus enters into the

picture in two ways, first in the reverberation room and secondly in the studio itself.

If conditions were similar in the two rooms, the degree of diffusion would tend to have only second-order effects, but this is by no means the case. A reverberation room is designed so that small samples of materials under test can be expected



2 *Sound-absorbing treatment in a television studio*
Measuring equipment is seen in the foreground

to provide a marked change in reverberation time. This is achieved by using a fairly small room and arranging for the minimum of absorption in the room other than that provided by the sample; in a typical case, a sample covering 7% of the surface area would be mounted in a tiled room with a volume of 3500 ft^3.

In some studios, on the other hand, every available square foot of surface area may be taken up by some form of absorbing treatment, and volumes vary between 1000 and 350000 ft^3. Figs. 1 and 2 illustrate the difference between a reverberation room and a typical television studio.

Distribution of absorbers

Theoretical and experimental work over the last few years has indicated that the degree of diffusion in a room is influenced by a number of factors, of which the most important are the size and shape of the room and the manner in which the absorbers are distributed over its surfaces. Fig. 3 shows how the measured absorption coefficient of a sample may vary in different conditions in the same room.

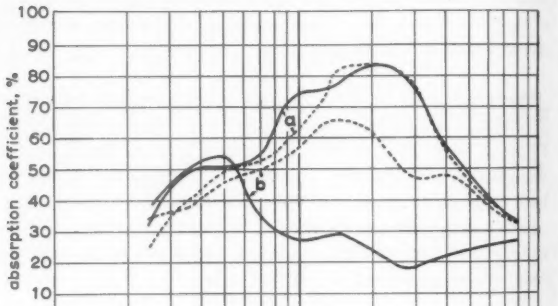
In the reverberation room, special measures may be required in order to nullify inaccuracies due to the inherently poor distribution of absorption, a problem which has engaged the attention of the International Organization for Standardization for some time. The difficulty is usually much less marked in a sound or television studio, but there have been occasions where poor distribution has been forced on the designer: for example, where a drama studio is required to be more reverberant towards one end than the other.

These considerations emphasize the desirability of being able to measure the degree of diffusion in a room. A large number of possible methods have been investigated by the B.B.C., all of which are statistical in nature, requiring a very large number of individual measurements.

Measuring the degree of diffusion

The most promising method is based on the study of the variation of the decay rate of sound throughout the period of the decay. When a tone is radiated from a loudspeaker, the decay of sound occurring when the tone is interrupted is basically exponential in conditions of good diffusion; and, when this process is reproduced on a level recorder or an oscillograph using a logarithmic scale, the trace produced, although exhibiting small oscillations, is essentially a straight line. The reverberation time is usually obtained by measuring the average slope of this line.

A change in the rate of decay, indicative of a poor degree



3 *Absorption coefficient of fixed area of absorber in various conditions*
—— no diffusers
– – – with diffusers
a distributed throughout the room
b concentrated on one wall

of diffusion, appears as a curvature of the line. A simple measure of the state of diffusion can be obtained by comparing the initial and final slopes of a large number of traces over the period of the decay.

Automatic measurement

Electronic apparatus is being developed for performing this operation automatically, in order to extend the study of the performance of absorbing materials in the laboratory and in the studio.

621.396.97 : 534.84

Slot-excited corner reflector

A synopsis of an Electronics and Communications Section paper (3303) entitled 'A slot-excited corner reflector for use in Band V (610–960 Mc/s)' by D. J. Whythe, B.Sc.(Eng.), Associate Member, and K. W. T. Hughes, B.Sc. The paper is published this month in Part B of the Proceedings. Mr. Whythe is with the British Broadcasting Corporation, and Mr. Hughes, formerly with the B.B.C., is now with Racal Engineering Ltd.

THE directional aerial discussed employs a corner reflector excited by a four-tier slotted cylinder. It was used during a series of test transmissions in Band V (610–960 Mc/s) which required an aerial capable of withstanding severe climatic conditions for long periods without attention.

A design suitable for operation at 900 Mc/s is described; the measured results include admittance characteristics and radiation patterns in the horizontal and principal vertical planes.

621.396.677.832

Resistive-film milliwattmeters

A synopsis of an Electronics and Communications Section paper (3298) entitled 'Resistive-film milliwattmeters for the frequency bands 8·2–12·4 Gc/s, 12·4–18 Gc/s and 26·5–40 Gc/s' by I. Lemco, B.Sc., and B. Rogal, B.Sc.(Eng.), Associate Members. The paper is published this month in Part B of the Proceedings. The authors are with the Wayne Kerr Laboratories Ltd.

THE authors describe a commercially developed version of a wide-band microwave milliwattmeter for the frequency band 8·2–12·4 Gc/s, based on Lane's principle of mounting a narrow resistive strip in the transverse plane of a waveguide. The instrument gives power measurements in the range 1–100 mW with an accuracy within ±2%. Effects of temperature are discussed, and a robust version of the milliwattmeter is mentioned. Two models designed on the same principle for the frequency bands 12·4–18 Gc/s and 26·5–40 Gc/s are also described.

Comparison of these with other power-measuring instruments indicates that the resistive-strip mounts are of high accuracy at these frequencies. This is obtained by the simplicity of design of these mounts, resulting in lower power losses.

621.317.784

Anode luminescence

A synopsis of an Electronics and Communications Section paper (3308) entitled 'Anode luminescence in oxide-cathode receiving valves' by H. N. Daglish, B.Sc., Ph.D., A.Inst.P., Graduate. The paper is published this month in Part B of the Proceedings. The author is at the Post Office Research Station.

DURING life test, Post Office underwater-repeater valves and other receiving-type valves exhibit a blue luminescent pattern on the inner surfaces of the anode. The nature and some of the properties of the luminescent material are examined, and it is concluded that the actual material is barium and/or strontium oxide transferred from the cathode coating during processing.

621.385.13.032.213

Synopses of papers

ON this page are synopses of papers published in the *Proceedings* which have not been read at Institution meetings and which have not been reviewed in the *Journal*. They are included here primarily for reference. Reprints will be available about two months after publication.

Pole-face losses in alternators

A synopsis of a Supply Section paper (3313) with the above title by Prof. J. Greig, M.Sc.(Eng.), Ph.D., Member, and K. Sathirakul, B.Sc.(Eng.), Ph.D., Graduate. The paper will be published in Part A of the Proceedings. Prof. Greig is William Siemens Professor of Electrical Engineering, and Dr. Sathirakul is in the Department of Electrical Engineering, King's College, University of London.

A RECENT re-examination of the phenomenon of tooth-ripple flux pulsations at laminated pole-faces in alternators resulted in a new theoretical analysis, by means of which the pole-face eddy-current loss can be calculated. The primary purpose of the present investigation has been to make measurements of tooth-ripple losses which could be compared with values calculated from the new formulae.

In order to make these measurements, an experimental homopolar machine was built, and values of eddy-current loss were determined over a fairly wide range of flux density and frequency for four different thicknesses of lamination.

It is found that there is moderately good agreement between calculation and experiment for the thicker laminations, and in general the agreement is markedly better with the new formulae than with those previously developed.

621.313.3.017.31

Speed-changing induction motors

A synopsis of a Utilization Section paper (3306) with the above title by Prof. G. H. Rawcliffe, M.A., D.Sc., Member, and W. Fong, Ph.D., Graduate. The paper will be published in Part A of the Proceedings. Prof. Rawcliffe is Professor of Electrical Engineering, and Dr. Fong is in the Department of Electrical Engineering, University of Bristol.

AN earlier paper has described the basic steps which led to a practical form of 8/10-pole induction motor, of good performance, having only one stator winding. The principle on which this speed-changing motor was based has been given the name of 'pole-amplitude modulation'. Since the publication of the original account of it, the principle has been further developed, and a number of improvements in the method have been devised and tested in practice on several new forms of 8/10-pole motor.

This paper discusses the theory and tests on these new machines, which are of interest both in themselves and for the further light which they throw on the principles of pole-amplitude modulation. The tests were completely successful, and this type of machine is now in the repertory of several manufacturers as an established industrial product.

621.313.333:621.316.718.5

PAPERS AND MONOGRAPHS

published individually this month

Papers accepted for reading at meetings, and monographs, are first published individually and are republished later in the Proceedings of The Institution; as soon as the separates are available, they are described in this feature. The papers are supplied free of charge; the price of a monograph is 2s.

In addition, reprints of papers read at meetings, including the discussions thereon, and of papers not read at meetings, become available, price 2s., within three months of their appearance in the Proceedings.

Applications quoting the serial number of the paper, monograph or reprint as well as the author's name, and accompanied by a remittance where appropriate, should be addressed to the Secretary of The Institution. For convenience, books of five vouchers for this purpose can be obtained in advance, price 10s.

Those who obtain a copy of a paper published individually are urged—if they do not take the Part of the Proceedings in which it will be republished—to apply in due course for a reprint, as this is the final and correct version and includes the discussion.

PAPERS

Determination of the electrical characteristics of an arc furnace *Paper* 3328U, *Part A*

J. RAVENSCROFT, B.SC.

THE author describes three different methods for the determination of the electrical characteristics of arc furnaces. A comparison is made between the three methods by applying each in turn to the determination of the electrical characteristics of a 10cwt Héroult-type 3-phase arc furnace.

In the first method, the characteristics are obtained directly from observations on the furnaces during normal operation and in short-circuit conditions; in the second method, the furnace curves are calculated by using an equivalent circuit for the 3-phase arc furnace; the third and most simple method treats the furnace as a balanced 3-phase load and utilizes a current-locus diagram to calculate operating points on the characteristics.

For the 10cwt furnace, the simple locus-diagram treatment gave results of sufficient accuracy for all practical purposes, and the characteristics show that the furnace is most efficient, electrically, when operated on the highest voltage tapping.

To be read on the 8th December 1960

Design and performance of high-precision audio-frequency current transformers *Paper* 3296M, *Part A*

J. J. HILL, B.SC., *and* A. P. MILLER

CURRENT transformers of existing design are found to have large high-frequency errors. The causes of these errors are examined, and it is shown that they are due to the high values of leakage inductance, self-capacitance and concentrated inter-winding capacitance that result from the conventional multilayer form of construction. Greatly improved performance can be obtained if the windings are arranged in uniformly-distributed single layers with a suitable thickness of insulation between them.

Approximate formulae for calculating the various constants and errors of a transformer having single-layer windings are given, together with a design procedure for any specified limit of error over a wide band of frequencies. The practical aspects of the design are also discussed.

Multi-ratio transformers in which all the ratios have virtually identical errors over a band of frequencies can be obtained by subdividing single-layer primary windings into sections, all of which are used by means of series-parallel connections for each ratio.

Details are given of the design and performance of precision single-layer multi-ratio transformers rated from 5/5 to 400/5amp. Their errors do not exceed 5 parts in 10^5 in ratio and 0·3′ in phase over the frequency range 400c/s–10kc/s and are less than 2 parts in 10^4 and 1′ over the range 50c/s–30kc/s.

To be read on the 10th January 1961

Techniques for the calibration of standard current transformers up to 20kc/s *Paper* 3297M, *Part A*

J. J. HILL, B.SC.

WHEN standard current transformers are tested at high audio frequencies, the errors and uncertainties in the measurements are liable to be great, owing to the effects of stray magnetic fields on the large unshielded resistors which of necessity have to be used. The sources of stray fields are examined, and means are suggested for substantially reducing them. It is shown that the 4-terminal resistance standards used in current-transformer testing bridges are very frequency-dependent, and present techniques limit the accuracy of measurement at 20kc/s to 2 parts in 10^4 in ratio and 0·8′ in phase.

New techniques are described by which the errors and uncertainties can be reduced to give an accuracy of 5 parts in 10^5 and 0·1′ at 20kc/s.

To be read on the 10th January 1961

MONOGRAPHS

Analytical review of power-system frequency, time and tie-line control *Monograph* 395S

D. BROADBENT, B.SC., M.ENG.SC., PH.D., *and* K. N. STANTON, B.E.

OVER the past decade and a half, there have been proposed three schemes of control for electric supply systems interconnected through tie lines. In chronological order they are the speed-governed system with frequency biasing, the time-governed system and the load-phase energy control.

The authors describe computer studies which compare the three systems using a performance index of the integral square error. Certain conclusions are reached by applying this criterion both to the frequency error of the isolated system and to the tie power-flow error of the interconnected system.

Magnetic excitation inside a cylindrical thin-film ferromagnet *Monograph* 396M

T. H. O'DELL, B.SC.

AN expression for the magnetic excitation inside a cylindrical thin-film ferromagnet is derived, and a table of computed values is given. The results are considered to be relevant to work on thin ferromagnetic films for digital-storage applications.

Matrix analysis of constrained networks *Monograph* 399E

A. NATHAN, M.S.

FOLLOWING a review of nodal analysis of unconstrained lumped linear time-invariant networks, it is shown how networks with imposed unilateral constraints, i.e. transmittances and voltage sources, can conveniently be analysed by matrix methods. Their admittance matrix is equal to the product of a submatrix of the admittance matrix before the application of the constraints and a transmittance matrix which describes the constraints. Constraints lower the rank of the original admittance matrix, thus making the method quite attractive in practice.

Applications included are a computing network, difference amplifiers, a d.c. amplifier and signal flow graphs.

Conductivity of oxide cathodes. Part 9—Thermoelectric power *Monograph* 397E

G. H. METSON, M.C., D.SC., PH.D., M.SC., B.SC.(ENG.), *and* M. F. HOLMES, B.SC.

THE thermoelectric power of an oxide cathode has been examined recently by J. R. Young, who finds it to be a complex function of temperature, dependent on the dual nature of oxide-cathode conductivity.

By an experimental artifice, the present authors show that an apparently complex form of behaviour is, in fact, the result of the superposition of two quite simple phenomena. Two parallel-acting thermoelectric power functions are involved, and each of these is invariant with temperature and temperature gradient. The two functions are physically separated, and each is measured over an appropriate temperature range.

The larger function, of magnitude 2·0 — 3·0mV/degC, is associated with the vacuum movement of electrons through the hollow pores of the oxide matrix; the smaller one, of magnitude 0·5mV/degC, occurs in the chains of contiguous solid particles of the matrix.

Owing to the parallel connection and inequality of these functions, it is concluded that a temperature gradient through an oxide matrix leads to a continuous circulation of current, vacuum-wise in one direction and solid-wise in the other. Since the larger function is essentially one involving thermionic emission of electrons in a vacuum, it can be satisfactorily explained in terms of Richardson's law.

Limitations on realizable response shapes for certain wide-band bandpass amplifier circuits *Monograph* 400E

R. A. WOODROW, B.SC.

A PROCEDURE is described for the design of wide-band bandpass amplifiers using either stagger-tuned stages or a chain of feedback pairs to realize Chebyshev or Butterworth response shapes.

A graphical test has been developed by which it is possible to verify, at the outset, that a given design specification is a realizable one. Certain fundamental limitations which are imposed on the response shapes by the choice of these circuit configurations are revealed by this test. Thus it is shown that any response shape which may be realized by a chain of feedback pairs can also be realized with stagger-tuned stages, while the converse is not true.

An example demonstrating the application of the procedure to a design problem has been included to demonstrate that the procedure for a Chebyshev response is no more complicated than for a Butterworth response, neither is any additional complication introduced by increasing the number of singularities in the desired response shape beyond the first pair, since each pair of singularities are separately realized.

Application of the theory of orthogonal polynomials in two variables to a multi-gain equivalent linearization problem *Monograph* 401M

J. L. BROWN, PH.D.

IT is shown that the multi-gain representation for a single-valued non-linearity with multiple inputs, as developed by Somerville and Atherton, may be regarded as an approximation problem involving orthogonal polynomials in two variables.

Consider two stationary random processes $x(t)$ and $y(t)$, possibly correlated, with a given second-order joint probability density $p(x, y)$. If the input to a specified, zero-memory, non-linear device having the input–output characteristic $v_o(t) = f[v_i(t)]$ is $x(t) + y(t)$, the relevant polynomials satisfy orthonormality conditions over the xy-plane with respect to $p(x, y)$ as weighting function. An inherent minimum property of these polynomials then allows the equivalent gains to be determined directly in terms of the expansion coefficients of $f(x + y)$ with respect to the polynomials. When x and y are uncorrelated, the gains reduce to the values previously obtained by Somerville and Atherton.

A further property of the polynomials is sufficient to prove that the error involved in the approximation is uncorrelated with the input, and that this result remains true as the order of the approximation is increased.

Forced oscillation in an oscillator with two degrees of freedom *Monograph* 398E

B. R. NAG, M.SC.(TECH.)

RESONANCE curves of an oscillator with two degrees of freedom and the criteria of stability of the synchronized state are determined theoretically by van der Pol's method of approximation and verified experimentally by an electronic differential analyser. An experimental method for obtaining the phase trajectories is described. Characteristics of oscillations outside the zone of synchronization are also discussed.

OBITUARY

WILLIAM ELLIS AFFLECK

With the death of William Ellis Affleck on the 28th June 1960 the industry has lost a man of great individuality and large experience, while those of us who knew him have lost a good friend.

A native of Hawick, he was born on the 26th November 1893 and educated at Trinity Public School and at Tiviot Grove Academy, Hawick. He joined the supply industry in the town in 1908 as an apprentice, studying part-time at Hawick Technical School. In 1912 he transferred to Stirling Corporation Electricity Department; in 1914 to Cleveland and Durham Supply Co.; and in 1915 to Holyhead Urban District Council. In 1916 he joined the Royal Navy. From 1919 to 1920 he served with Stafford Corporation. He then went, as assistant manager, to Guildford Electric Supply Co., and when the corporation took over the undertaking in 1921 he was appointed chief engineer and manager. In 1948 he became district manager for Guildford.

He had the satisfaction of seeing the Guildford undertaking grow from very small beginnings into a large supply organization meeting the needs of 30000 consumers. But his activities were not confined to his professional responsibilities. He took a very active interest in the affairs of the town. Among other things he was honorary adviser on lighting of churches to the Guildford Diocesan Committee; founder and secretary of the Guildford Scottish Society; an early member and later president of the Rotary Club; and he worked hard to raise funds for the new Guildford Cathedral.

In his spare time he was a keen fisherman, gardener and golfer. He is survived by his widow and two married daughters.

He joined The Institution as an Associate Member in 1933 and was elected a Member in 1941. C. W. H.

ROBERT HAMILTON BARCLAY

Robert Hamilton Barclay who died on the 27th March 1960 was born on the 10th August 1887. He was educated at Washington University and received practical training with Laclede Power Co., St. Louis, and with Hartford Electric Light Co.

He spent nearly all of his career, spanning more than 50 years, in the practical application of the principles of electrical science. His work covered both communication and power engineering, in design and in administration of important projects, as well as in the administrative and regulatory functions of Governmental agencies. Among his achievements he counted the design of the Conowingo hydroelectric plant as outstanding.

His interest in engineering extended beyond the workday into the spheres of professional advancement and recognition, and he spent much time and effort in working toward improving public understanding of the aims and responsibilities of the engineer *vis-à-vis* the public.

In addition to a lifelong avocation in wireless from the early days through the latest advances, he had a great avidity for photography. His interesting tales of his travels and other interests were

Obituary (continued)

frequently punctuated with pictorial supplements. He took great pride both in the long history of his family in the United States and in the family origins in England. He was the last of his line in the United States.

His wide and varied acquaintanceship both within and without the profession was a source of much pleasure to him and to his friends.

He is survived by his widow.

A long-time Fellow of the American Institute of Electrical Engineers, he served as committee member and chairman for the Institute and for the Engineers' Council for Professional Development and the Engineers' Joint Council.

He joined The Institution as a Member in 1953 and from then until his death served as Honorary Secretary of the Council for the United States of America. G. H. O'S.

SIR FRANCIS BRAKE

Sir Francis Brake who died on the 13th June 1960 was born on the 10th December 1889. He was educated at St. Paul's School, Hammersmith, and Mountjoy School, Dublin.

In 1908 he joined the National Telephone Co. as an apprentice and in 1912 transferred to the Western Electric Co., afterwards to become Standard Telephones and Cables.

During the First World War he served in France and the Near East, first in the 1st King Edward's Horse and later in the Royal Horse Artillery.

After the war he returned to Western Electric, becoming chief equipment engineer and later sales manager. In 1924 he was appointed managing director of the Scandinavian associated company of the International Western Electric Co. Returning to London in 1926, he became general sales manager and then technical director of Standard Telephones and Cables.

In 1933 he was appointed managing director of Creed and Co. and held this position until 1957, constantly exercising in that capacity his energetic personal leadership in spite of his additional wartime and other duties.

In 1940 he was called by Lord Beaverbrook to join the Ministry of Aircraft Production with the duty of safeguarding production by arranging for dispersal of key facilities. He became controller of production and regional services and a member of the Air Supply Board. He was knighted in 1946.

In 1947 he was invited by the Prime Minister to act as a director of British South American Airways Corporation, and following the subsequent amalgamation with British Overseas Airways Corporation he joined the board of the latter and served until 1958. He was, until his death, also a director of B.O.A.C. Associated Companies.

He was a vice-president of the International Standard Electric Corporation; a director of Standard Telephones and Cables and of a number of associated companies; and a director of E.P.S. (Research and Development).

Sir Francis was a man of engaging personality and of wide interests. He was a member of the Worshipful Company of Gold and Silver Wyre Drawers and a freeman of the City of London. He was a life-governor of Haileybury and Imperial Service College and a member of the council of Milton Abbey School.

He married in 1914 and is survived by his widow.

He joined The Institution as an Associate Member in 1919 and was elected a Member in 1935. C. E. S.

HUGH CLARK

Prof. Hugh Clark, B.SC., who died on the 8th May 1960 was born in Southsea, Hampshire, on the 9th February 1888. He was educated at Smythe's Academy and at Mile End House School, Portsmouth, and at Portsmouth Technical College. In 1908, having passed the intermediate B.Sc.(Eng.) examination, he proceeded to City and Guilds College, University of London, to study electrical engineering. In 1909 he was awarded the John Samuel Scholarship as the best student of the year, and in 1910 he obtained an honours B.Sc.(Eng.) degree.

In 1911 he served a pupilage with the Western Electric Co., North Woolwich, having previously served an apprenticeship from 1904 to 1906. In 1911 he became a lecturer in electrotechnics at Natal Technical College and was later appointed head of the department of electrical engineering, physics and mathematics. In 1918 he undertook the training, in the electrical trades, of soldiers who were returning from the First World War, and he served on the committee administering the Governor-General's War Fund.

In 1920 he went to England to do postgraduate work at City and Guilds College and was awarded the Diploma of Imperial College.

Returning to Durban, he read a paper in 1921 to the Natal Institute of Engineers on the electrification of the Natal main railway, as a result of which the Government decided to electrify the Natal section of the Durban–Johannesburg line instead of the section from Volksrust to Johannesburg. He was author of a number of papers read before the Natal Institute of Engineers and the South African Society for the Advancement of Science (Section A), of which Section he was president in 1938.

In 1922 he was appointed professor of electrical engineering at Natal University College, a position he held with distinction until he retired in 1953. In 1936 he was granted two patents by the Patent Office, London. During the Second World War he was officer commanding the Radio Communications Training Centre of the South African Corps of Signals.

On his retirement he went to live in Rhodesia, but returned to Durban in 1958. While in Rhodesia he was asked by the Electricity (Shadow) Supply Commission of Nyasaland to report on the electric power requirements of the Southern Province of Nyasaland for the period 1956 to 1965.

He was a fine man and a fine engineer. His enthusiasm and his inventive capacity provided evidence of the latter, while his human qualities and his power to direct and inspire his students proved him to be the former.

He joined The Institution as a Student in 1910 and was elected an Associate Member in 1913 and a Member in 1934. J. H. N.

FRANK POWNALL EGERTON

Frank Pownall Egerton, C.B.E., who died suddenly on the 17th June 1960 was born on the 8th January 1900. He was educated at King Edward VI School, Stafford, and part-time at Manchester University after serving an apprenticeship at Crewe locomotive works.

In 1926 he joined the electrical department of the Federated Malay States Government, with which he served until the fall of Malaya in 1942. In 1946 he became director of electricity and with the formation in 1949 of the Central Electricity Board, of which he was the architect, its first general manager and deputy chairman. He retired in 1953, being appointed a Commander of the Order of the British Empire, and until his death was employed as a consultant by Messrs. Preece, Cardew and Rider.

He served in the Royal Navy during the 1914–18 War and in the Army with the rank of colonel during the Second World War.

His outstanding characteristics were transparent honesty, devotion to duty, kindness and loyalty to his friends. He was a keen Freemason, being an officer of Grand Lodge, and his hobbies included model-making, golf and photography. He is survived by his widow, Kathleen; with their daughter and son they formed a devoted family.

He joined The Institution as a Student in 1922 and was elected an Associate Member in 1927 and a Member in 1938. He served as chairman of the Singapore/Malaya Joint Group from 1948 to 1952. C. H. P.

ALBERT VICTOR FRANCIS

Albert Victor Francis who died on the 22nd May 1960 after a brief illness was born on the 4th March 1915. A Worcester man, he received his education at Worcester Technical School and part-time at Worcester Technical College and at Chance Technical College, Smethwick.

After an initial period of five years with Heenan and Froude, Worcester, and a short time with Birlec, Birmingham, he joined Metalectric Furnaces, Smethwick, in 1936, and over the next 13 years he received his practical training and subsequently held the position of chief draughtsman.

In 1949 he joined G.W.B. Furnaces, Dudley, as sales and development engineer, and after six years' intensive work he was appointed chief engineer. His work initially involved him in the application of resistance-heated furnaces, but later he took over the supervision of design, application and manufacture of arc and induction melting furnaces. His last years' work was rewarded by the securing for his company of the contract for the two largest arc furnaces to be built by a British firm.

He will be remembered by his friends and colleagues for his immediate grasp of engineering detail and his outstanding capacity for work.

'Vic' was a home-loving man and latterly he found great pleasure in the design and building of a new house and the planning and laying out of the garden. He is survived by his widow, a son, who is continuing his engineering studies at Manchester University, and a daughter.

He joined The Institution as an Associate Member in 1948 and

was elected a Member in 1956. He was an Associate Member of The Institution of Mechanical Engineers. E. J. H.

CECIL MARSDEN PERRIN

Cecil Marsden Perrin who was born in Ireland in 1882 died on the 1st May 1960 at Toowong, Brisbane, Australia. He was educated at St. Andrew's College, Dublin, and part-time at Dublin College of Science and at University College, Nottingham, while apprenticed for three years to Brush Electrical Engineering Co., Loughborough.

In 1904 he became a charge engineer with the County of Durham Power Distribution Co. and in 1905 assistant mains engineer with Newcastle Electric Supply Co. In 1913 he joined British Insulated and Helsby Cables, Prescot, as contract engineer and became a pioneer in the installation of h.v. cables on electric power systems in the north of England, the United States and China.

In 1917 he joined Shanghai Municipal Electricity Department as distribution engineer and in 1929 transferred to the successor, Shanghai Power Co., in the same position. He was appointed head of the engineering department in 1934, which position he held until 1941 when he retired to Australia.

'C.M.P.', as he was affectionately known, was of a quiet and calm disposition; although exacting in his professional requirements, he was most friendly and helpful to his staff and colleagues. He led by example and created an atmosphere in which team-work and efficiency thrived. Many around the world will warmly recall their friendship with him.

His chief hobby was his work, but during holidays and home leaves his main interests were world travel, curio collecting and photography. He is survived by his sister.

He joined The Institution as an Associate Member in 1913 and was elected a Member in 1925. He was vice-chairman of the China Local Centre in 1937–38. W. H.

TECHNICAL PUBLICATIONS

ORGANISATION FOR EUROPEAN ECONOMIC CO-OPERATION

Machinery Committee. Trends of European exports of engineering products to less industrialized countries. O.E.E.C., Paris, 1960. n.p.

THIS report represents the first conclusions from studies of the competition by non-member countries in third markets, and includes two statistical pilot surveys, one dealing with Latin America and the other with India.

POST OFFICE

Safety precautions relating to intense radio-frequency radiation. H.M.S.O., London, 1960. 9d.

THE booklet, which is the report referred to in the Foreword of the May 1960 *Journal*, p. 267, recommends precautions to be taken at certain types of radio and radar transmitting stations and research and experimental establishments for the protection of the public and of operating and maintenance personnel from the possible harmful effects on the human body of intense r.f. radiation.

TELECOMMUNICATION ENGINEERING AND MANUFACTURING ASSOCIATION

Annual report 1959–60. T.E.M.A., London, 1960. n.p.

WORLD telephone progress, Post Office business, exports and new telecommunication services are discussed in this report.

UNITED KINGDOM ATOMIC ENERGY AUTHORITY

Training in radiological health and safety. H.M.S.O., London, 1960. 5s. 6d.

THIS is the report of the committee set up by the Authority under the chairmanship of Sir Douglas Veale. Methods of training at three levels are considered, ranging from university postgraduate courses (some have already been set up) to certificate courses at technical colleges. A national training centre is thought unnecessary. A national advisory service, however, should be set up to advise organizations without full-time health specialists. The committee recommend that medical schools might include in the basic curriculum simple instruction in the use and hazards of ionizing radiations.

AERE–M563 **The distribution of currents on the surface of a toroidal conductor** by R. J. Tayler. Harwell, 1960. 3s. 6d.*

THE author shows how the distribution of currents flowing on the surface of an ideally conducting torus can be calculated when all the currents flow in the direction of the major circumference of the torus. Results are given for four values of the torus aspect ratio between 3 and 6.

AERE-Lib/L1 **Sources of information in atomic energy** by L. J. Anthony. Harwell, 1960. 6s.*

THIS report lists the various Government agencies responsible for issuing technical reports and other information, the functions and addresses of the international atomic-energy bodies, and reference books, periodicals and abstracting journals.

AERE–M578 **Neutron flux measurement in the beam hole on Lido** by J. M. Ponce de Leon and C. J. Kenward. Harwell, 1960. 1s. 9d.*

THERMAL, epithermal and fast neutron fluxes have been measured in the central beam hole on the north-west side of Lido, by foil-activation techniques and cadmium-ratio determinations.

AERE–R3075 **High frequency properties of a uniform plasma. Part II—Effect of a uniform magnetic field** by J. Randles. Harwell, 1959. 9s.*

PART I (AERE–R2916) dealt with h.f. motion in a plasma free of constant external fields. Part II considers the effect of a uniform magnetic field on this motion.

AERE–R3085 **Some effects of radiation in cast epoxide resin systems** by I. D. Aitken and K. Ralph. Harwell, 1960. 4s. 6d.*

CHANGES in the flexural strength due to pile irradiation of cast epoxide-resin systems have been measured. The effect of various types of curing agent on the rate of breakdown is shown.

AERE–R3097 **A method of computing magnetic fields and particle orbits in f.f.a.g. accelerators** by R. Taylor. Harwell, 1959. 2s. 6d.*

A METHOD is described of obtaining the magnetic-field components as functions of position, particle orbits, and the frequencies of small-amplitude radial and vertical oscillations, in accelerators having the dynamic scaling property of fixed-field alternating-gradient fields that orbital geometry is independent of momentum.

AERE–R3250 **Small sample techniques for slow neutron total cross-section measurements** by G. S. G. Tuckey. Harwell, 1960. 1s. 9d.*

THE author discusses the design and performance of the sample changer used in the small-sample chopper. A description is given of the sample techniques used, including the methods of determining the bores of the tubes, and the techniques for filling the tubes with milligramme quantities of material.

AERE–R3292 **A general purpose two channel coincidence unit A.E.R.E. type no. 2013A** by F. H. Wells, G. L. Godfrey and A. K. Barlow. Harwell, 1960. 2s. 6d.*

THE unit described is a two-channel coincidence or anti-coincidence unit for use in the range 0·1–5 microsec, employing semiconductor circuit-elements throughout.

* Obtainable from H.M. Stationery Office

Technical publications (continued)

Glossary of atomic terms. H.M.S.O., London, 1960. 3s. 6d.
Some 500 terms in common use are explained.

UNITED NATIONS

The electric power situation in Europe in 1958–59 and its future prospects. Geneva, 1960. 5s.*

VARIOUS developments in the electric power industry are analysed, and the report contains for the first time more detailed information concerning medium-term forecasts. These imply that average European requirements per head in 1965 will be 2050 kWh (an average rise in consumption of 9% over 1955, compared with a rise of 9·3% between 1951 and 1955). The report contains chapters on the consumption of electric power in 1958, future tendencies in electric power consumption, generating capacity and production of electric power, transmission networks and international exchange, and capital expenditure and related questions.

* Obtainable from H.M. Stationery Office, P.O. Box 569, London S.E.1

SOME RECENT BOOKS

MOTOR SELECTION AND APPLICATION

C. C. LIBBY

McGRAW-HILL. 1960. 508 PP. £5 4S. 6D.

THIS is a collection of information required for the application of electric motors 'for industrial service'. The three words quoted, which appear in the preface, ought to be included in the title, which is otherwise rather misleading. The book is concerned only with motors used in factories, and does not deal with such fields of application as ships, aircraft, farms or the home. Thus single-phase motors are hardly mentioned, and electric traction receives little attention.

For factory applications, the treatment is very thorough indeed. The greater part (eight chapters) is devoted to 3-phase induction motors; synchronous and d.c. motors have only one chapter each, although many matters, like heating and enclosure, discussed in the earlier sections, apply to them also. Much of the material is closely related to the very detailed American system of standardization (N.E.M.A. and others) and is of less value to British readers for this reason. It is mainly a statement of present-day practice and does not look to the future to any extent. There is little discussion of the ways in which the standards ought to be changed. Finally, if it be accepted that the objective of any student must be to learn how to think, rather than to collect information, the claim that the volume is of value to students can hardly be justified.

B. ADKINS

FUNDAMENTALS OF ELECTRONICS

E. N. LURCH

NEW YORK: JOHN WILEY. LONDON: CHAPMAN AND HALL. 1960. 631 PP. £3 6S.

ACCORDING to the author's preface, this work is written specifically for the 'technician' working in the electronics field. It gives a combined presentation of the transistor and the thermionic valve, and claims to provide a background of fundamentals for applications so diverse as communications, industrial electronics, television and computer systems. From a superficial inspection of its content, it would appear possibly to perform its stated function, though with a strong bias towards communications: a physical treatment of semiconductor and thermionic devices is followed by material on a.c. circuits, rectification, various types of amplifier, feedback, oscillators, modulation, detection, and the cathode-ray oscilloscope.

Detailed reading reveals that the text, while giving a conventional though somewhat tedious presentation of long-established topics, is a most unreliable guide to more recent developments in electronics. The most serious criticism is in regard to inaccuracy of treatment of fundamental semiconductor-device principles: for the most part, the explanations of device mechanisms are grossly incorrect, and one can only conclude that the author does not himself understand them. Apart from a chapter on relaxation oscillators, little concession is made to fields of electronics outside communications, and here only a superficial description of a few specific circuits is given, with no systematic treatment of the switching properties of valves and transistors.

It is difficult to recommend this volume to the serious-minded reader who wishes to understand the physical mechanisms concerned in modern electronic devices. To the student, the incorrect presentation of fundamentals can only be a source of confusion, while the general user of transistors and valves will find in other books a more satisfactory treatment of the circuit principles underlying their application.

A. R. BOOTHROYD

ADVANCES IN ELECTRONICS AND ELECTRON PHYSICS—Vol. 11

L. MARTON (*Editor*)

NEW YORK: ACADEMIC PRESS. 1959. 523 PP. $15

IN recent years, the scientist has found it increasingly difficult to keep up to date with published developments in his field. The task has been immeasurably eased by the regular appearance of authoritative reviews like the present book, the eleventh in its series.

Even within the limitations of the title there is much scope, and it is perhaps not surprising that the eight chapters treat a wide diversity of subject.

A fairly closely related trio are 'Recent advances in photoemission' by P. Görlich; 'Secondary electron emission from solids' by O. Hachenberg and W. Brauer; and 'Quantum efficiency of detectors for visible and infra-red radiation' by R. Clark Jones. The first two of these deal with the underlying physics of the emission processes, and the last is a comprehensive treatment of detector performance as limited by photon noise.

'Electron diffraction structure analysis and the investigation of semiconducting materials' by Z. G. Pinsker (translated by Lewis B. Leder) is largely an account of Russian work in this

interesting sphere. The non-specialist will find 'Parity conservation in weak interactions' by R. M. Sternheimer rather heavy going.

There are three sections with a bent towards electronic engineering. 'Radio telemetering' by Henry B. Riblet reviews advances since 1952, with emphasis on the practical side, whereas 'Operational amplifiers' by R. L. Konigsberg is largely a theoretical discussion of the topic. Finally, 'Automatic data-processing in the physical sciences' by G. E. Barlow, J. A. Ovenstone, and F. F. Thonemann, after discussing the delegation of the routine part of experiments to machines, strikes a sobering note with the remark that the 'speed [of electronic machines] can be used to augment the production of scientifically trivial results by orders of magnitude'.

This volume is well up to the standard set by the series but, on balance, will appeal more to the physicist than to the electronics engineer. V. ROBERTS

AN INTRODUCTION TO STATISTICAL COMMUNICATION THEORY

D. MIDDLETON

McGRAW-HILL. 1960. 1140 PP. £9 14s.

SOME justification is needed of the word 'introduction' in the title of a volume of 1140 pages, and perhaps a more explanatory title would have been 'Foundations of statistical communication theory'; for the author's intention appears to be to provide the budding communication engineer with a good grounding in the relevant theories. Although the author insists that the treatment is 'introductory' in the sense that in many topics there is further information to be gained from the 500 references included (with publication dates apparently up to 1958), the treatment is at postgraduate level and requires the reader to be familiar with present-day engineering mathematics and to have some knowledge of circuit theory, radio, radar and electronic devices.

Parts 1, 2 and 3 are based on graduate courses which the author gave at Harvard between 1949 and 1954, and Part 4 is founded largely on his original work. One would have to live with this publication for a year or two in order to be able to review it critically, and the following remarks are of necessity based on a sampling technique.

The mathematical treatment is throughout at the high level which one associates with the author and the two institutions at which he has worked; but this does add to the difficulty of using the book for reference, since most sections contain references to mathematical results of preceding paragraphs or earlier chapters.

Part 1 (330 pp.) deals with statistical techniques, sampling and interpolation, the effect of non-linear circuits such as rectifiers on signals and noise, and the general ideas of communication theory. Part 2 (173 pp.), on 'Random noise processes', includes a most valuable section on the equations of Langevin, Fokker–Planck, and Boltzmann; and it also has a chapter on physical sources of noise. Part 3 (260 pp.) discusses the application of the theory to various practical problems, such as different modulation systems, measurements, and prediction and filtering. Part 4 (295 pp.) is entitled 'A statistical theory of reception' and is largely concerned with decision procedures and the loss of information associated with them. It is claimed that the bulk of the material in Part 4 has not previously been published.

One may question the wisdom of attempting to cover so wide a field in a single work, which is then necessarily bulky and costly. Perhaps the author's defence would be that he needs to use in the last part much of the material which he has gathered into the first three parts.

It is, as the author insists, an introductory text, in the sense that for any specific point the reader may well wish to follow up the references which are given to original papers. But it is not easy reading and should not be attempted by the man who seeks an 'introduction' to the subject in the sense of identifying the essential principles and results without too much detailed study. Neither does it serve as a ready-reference for the man who has a modest acquaintance with the subject-matter; but it can be recommended to the professional worker in this sphere as a text for prolonged study or to the research worker as a source book. D. A. BELL

ELECTRONIC CIRCUITS, SIGNALS, AND SYSTEMS

S. J. MASON and H. J. ZIMMERMANN

NEW YORK: JOHN WILEY. LONDON: CHAPMAN AND HALL. 1960. 616 PP. £5

THE title is a little misleading, since it implies that the subject-matter is concerned mainly with practical electronic circuits. This is actually an advanced treatise on the network-analysis techniques applicable to electronic and communication circuits.

The initial chapters deal with matrix circuit analysis, topological circuit analysis, linear signal flow graphs and their applications to circuit analysis. Then follows a section on signal analysis, which introduces the correlation function, the Fourier integral and Fourier series, and applies them to the analysis of pulse, periodic, and random signals. These analytical methods are used in the next chapter to study the transmission of signals through linear networks. In this section the Laplace transform and contour integration are also discussed, and the behaviour of networks is examined by means of poles and zeros. The penultimate chapter considers a wide variety of modulators under the title of non-linear systems, and the last section introduces the negative-feedback concept and examines stability criteria.

This is one of the M.I.T. 'core curriculum' series, and is a companion volume to 'Electronic circuit theory' by the same authors. It is intended to be a textbook for advanced students in electrical engineering. The work is too advanced for undergraduates following a three-year general course in electrical engineering, but is very suitable for postgraduate courses in light-current engineering. The material is very well presented and easy to follow, and the authors have been careful to ensure that the practical applications of the theoretical matter are illustrated by analyses of many well known circuits. Each chapter is provided with a large selection of problems for the student. The book can be strongly recommended to advanced students and to teachers of electronics and communications. F. C. WIDDIS

Some recent books (continued)

JUNCTION TRANSISTORS IN PULSE CIRCUITS

P. A. NEETESON

PHILIPS TECHNICAL LIBRARY. 1959. 139 PP. 27S.

THIS book follows the author's 'Vacuum valves in pulse technique' in the same series and is based on his experience in the Application Laboratory of the Philips Company at Eindhoven.

After a short introduction on the properties of ideal and real switches, the author classifies basic pulse circuits into three categories: pulse generators, pulse shapers or regenerators, and pulse frequency-dividers and level-switches. He points out that the junction transistor is a more nearly perfect switch than the vacuum tube and that, in consequence, the analytical treatment of the above circuits using junction transistors is of simpler form than that of vacuum-tube circuits.

Examples of each of the above categories are analysed in detail, the author's aim being to derive simple formulae on which practical designs can be based. For example, in the case of the astable multivibrator, he derives expressions for the frequency of the circuit, the power dissipation in the collector and in the base, and the condition necessary to ensure bottoming of the transistor. Approximations are made to keep the formulae simple, and the author quotes experimental results in confirmation of the theory.

Similar treatment is accorded to the free-running blocking oscillator, the monostable multivibrator, the triggered blocking oscillator and the bistable multivibrator used as a frequency-divider and voltage-level-switch. The transient behaviour of the bistable multivibrator is also considered. Two brief additional chapters on auxiliary circuits and on applications complete the volume.

The work can be very warmly welcomed. It treats the subject in a logical manner and provides the minimum amount of information needed by the designer who wishes his circuits to work first time. It should be very widely read.

C. W. OATLEY

TELEPRINTER SWITCHING

E. A. ROSSBERG and H. E. KORTA

NEW YORK: VAN NOSTRAND. 1960. 351 PP. £3 10S.

THIS work is of such a comprehensive character that it should be in the hands of all studying communication engineering and of engineers responsible for the planning and development of teleprinter installations.

Hitherto, the various aspects of the problem have been dealt with by scattered papers in the technical Press, as indicated by the voluminous bibliography at the end of the book. This volume, however, itself presents, in its 350 pages and 208 illustrations, a comprehensive survey of teleprinter-switching systems all over the world.

The two authors have been intensively engaged for some 30 years in the development of switching methods for teleprinters and occupy key positions in a firm of communication-apparatus makers of international repute.

Subscriber-to-subscriber systems, as well as systems covering a nation-wide network, are adequately covered. Manual switching, queuing methods, international switching, multiplex operation and the determination of line quantities for various classes and quantities of traffic are fully dealt with. There is hardly any problem facing the planner on which some guidance is not obtainable.

The development of telex in European countries is fully described, and interworking of key sending and dial calling methods of setting up a route are explained.

H. H. HARRISON

FERRITES

J. SMIT and H. P. J. WIJN

PHILIPS TECHNICAL LIBRARY. 1959. 369 PP. £3 12S.

THIS is a publication on the physical properties of ferrimagnetic oxides in relation to their technical applications, written by two research physicists actively engaged in laboratory work on these materials.

It is in four parts. The theory of ferromagnetism, ferrimagnetism and magnetic processes is dealt with in the first part in six chapters. The second part is a single section on magnetic measurements. Three chapters cover the intrinsic, single-crystal properties of ferrites of spinel, hexagonal and garnet structures, respectively. The fourth part, of six sections, describes the structure and properties of polycrystalline ferrites.

It will be of value to physicists and chemists engaged in research on or development of these materials, and who already have a good basic knowledge of ferromagnetism and ferrimagnetism. Less-advanced readers may consider the book difficult if not, indeed, rather frustrating. Specialists in this field, however, will find it stimulating in much of the discussion, full of accurate and authoritative magnetic data and bringing together in one volume the results of a vast amount of experimental work otherwise to be found only in recent voluminous literature. Over 200 references to published research are given.

F. BRAILSFORD

MAGNETIC SOUND RECORDING

D. A. SNEL

PHILIPS TECHNICAL LIBRARY. 1959. 217 PP. 25S.

THIS small book makes its primary appeal to the engineer-owner of a tape recorder anxious to know something of the basic principles and the practice of tape recording. It is clearly not aimed at the specialist in the subject.

The whole topic, from sound waves in the studio to the acoustic treatment of the replay room, is reviewed in 24 chapters, including an interesting historical survey of the development of magnetic recording. It is salutary to be reminded that it took nearly 50 years to develop the cotton thread loaded with iron powder (suggested as a sound-recording medium by Oberlin Smith in 1886) into the p.v.c. tape loaded with iron powder now universally used for all professional recordings.

About half the total space is devoted to a good account of the magnetization process, the problems of obtaining a mechanical-drive system free from even minor speed irregularities, and the properties of recording tapes. The treatment varies considerably in technical level, the recording process

being treated in appreciable detail while some of the other chapters are rather superficial.

Roughly 20 pages are devoted to a survey of some 50 applications for tape recorders, while an equal amount of space is covered in dealing with the practical problems of using a tape recorder. The index, illustrations and printing are excellent, but there is no bibliography; nor indeed are there any references, a surprising omission in view of the contributions made to the art by Westmijze of the author's own organization.

A professional engineer engaged in the sound-recording field might well take issue with some of the statements, such as the 'definition' of the phon (p. 6): '74 phons is equivalent to a sound pressure of one dyne/sq cm for a 1000c/s note'. If definitions are to be given, and nine pages are devoted to them, it seems preferable to use the internationally agreed wording wherever possible. This particular 'definition' of the phon is too easily misinterpreted to be of any value.

Though obviously not intended for the professional engineer in the sound-recording sphere, the volume contains a great deal of information of value to the amateur having an engineering background.

J. MOIR

**Denotes that the publication is also in the Lending Library. The publications cannot be bought through The Institution; the publishers and the prices are given only for the convenience of members*

LIBRARY ACCESSIONS

BOOKS

ATABEKOV, G. I. 621.316.9

The relay protection of high voltage networks

London and New York: Pergamon Press, 1960. pp. xii, 564. 25·5 × 16cm. £4 4s.

This is a translation of the Russian edition published in 1957. It deals with the theoretical aspects of the subject and is intended for the specialist reader. This book will be reviewed in a future issue.

BERENDS, E. G. 654.19

Funk Atlas (Radio atlas)

Berlin: Verlag Sport und Technik, 1959. pp. 198. 30 × 21·5cm. 37s. 6d.

Charts and tables in German, Russian and English, giving information, mostly of interest to amateurs, on television and short- and ultra-short-wave commercial stations, including standard-frequency, weather and time-signal stations.

BRENNER, E., and JAVID, M. 538.551

Analysis of electric circuits*

New York and London: McGraw-Hill, 1959. pp. xv, 703. 23 × 15·5cm. £3 14s.

This book for advanced students is a new approach to an understanding of circuit behaviour. It avoids the artificial division into d.c., a.c. and transient states, which are particular cases of a general circuit response. It takes the differential equation of a circuit as its basic feature and all analysis stems from this. This book was reviewed in the February 1960 *Journal*, p. 118.

BUKSTEIN, E. 518.5

Digital counters and computers*

New York: Rinehart, 1960. pp. vii, 248. 23·5 × 15·5cm. £2 16s.

A practical book dealing with the circuitry of the various parts of computers—pulse generators, counting circuits, memory devices, counting systems, and digital–analogue and analogue–digital convertors.

CARTER, H. 621.317.755

An introduction to the cathode ray oscilloscope. 2nd edition*

London: Cleaver-Hume, 1960. pp. x, 121. 25 × 15cm. 15s.

Written mainly for technicians, apprentices and others not familiar with electronics, it gives a simple non-mathematical account of the operation of cathode-ray tubes, and the principles and circuits used in constructing oscilloscopes. Applications for various measuring and testing purposes are also described.

COLCHESTER, C. D. 621.396.93

Air traffic control

Chelmsford: Marconi's Wireless Telegraph Co., 1960. pp. 100. 24 × 16cm. 17s. 6d.

This originated as a study report on future electronic requirements for air-traffic control. It surveys the progress of the various systems in use today, including radar and navigational aids, and direct communication, and indicates the direction in which future development is needed.

FRANCIS, G. 537.52

Ionization phenomena in gases*

London: Butterworths Scientific Publications, 1960. pp. vii, 300. 22 × 14cm. £3

This is a work for the closing period of a degree course or for those beginning to do research, and for this reason it does not deal with the more well-known discharges. It discusses the physical principles of the behaviour of ionized media, alternating and high-frequency discharges, ionization and excitation in the upper atmosphere, high-current discharges and thermonuclear effects. This book was reviewed in the August 1960 *Journal*, p. 502.

GIBSON, A. F., and others (*Editors*) 621.315.59

Progress in semiconductors—Vol. 4*

London: Heywood, 1960. pp. vii, 291. 25 × 15·5cm. £3 3s.

This volume contains eight papers, on noise in semiconductors, negative-effective masses in semiconductors, oxidation phenomena on germanium surfaces, theory of avalanche multiplication in non-polar semiconductors, internal field emission, the electrical effects of dislocations, dielectric properties of solids in relation to imperfections, and non-crystalline and amorphous and liquid electronic semiconductors. This book was reviewed in the April 1960 *Journal*, p. 241.

GILLIE, A. C. 621.314.7

Transistors*

Englewood Cliffs: Prentice-Hall, 1959. pp. xvi, 262. 24 × 15·5cm. £2 2s.

A simple explanation of the transistor and its applications. This book was reviewed in the November 1959 *Journal*, p. 662.

HINSLEY, J. F. 620.17

Non-destructive testing*

London: Macdonald and Evans, 1959. pp. xxxiv, 495. 23 × 15cm. £3 15s.

A survey of the methods used for non-destructive testing, including those using X-rays and γ-rays, ultrasonic vibrations, and magnetic properties. This book was reviewed in the February 1960 *Journal*, p. 120.

Library accessions (continued)

HOBBS, M. 621.396.9

Basics of missile guidance and space techniques—Vols. 1 and 2*

New York: John Rider. London: Chapman and Hall, 1959. Vol. 1, pp. vi, 144. Vol. 2, pp. iv, 146. 23·5 × 15·5cm. £3 3s.

A simple descriptive account of the methods used to guide long- and short-range missiles to their targets. These two volumes explain the use of radar for locating the target; radio for communicating with and controlling the missile; and telemetering and instrumentation for recording observations in outer space.

HUTTER, R. G. E. 537.54

Beam and wave electronics in microwave tubes*

New York and London: Van Nostrand, 1960. pp. xii, 378. 24 × 16cm. £3 13s. 6d.

This comprehensive book analyses the basic physical principles of a range of microwave devices from klystrons and magnetrons to travelling-wave tubes. It deals first with normal fast-waveguides and then with beams in gaps, drift regions and slow-waveguide structures. Energy conversion is considered, and finally ideas on mode coupling and noise are discussed. This book will be reviewed in a future issue.

KNIGHT, H. de B. 621.385.38

The arc discharge: its application to power control*

London: Chapman and Hall, 1960. pp. xix, 444. 22·5 × 14cm. £3 3s.

This deals with the use of such valves as thyratrons, ignitrons and excitrons for the control of electrical power. It describes the construction and characteristics of the different types and their behaviour in various rectification and control circuits. This book was reviewed in the July 1960 *Journal*, p. 449.

MARTER, D. H. 536.8

Thermodynamics and the heat engine

London: Thames and Hudson, 1960. pp. xi, 811. 22 × 14 cm. £3 3s.

A work for students in the initial years of a degree course or equivalent. In keeping with modern ideas, it develops the subject as rigorously as possible, consistent with an elementary treatment, but the practical aspect is covered by descriptions and illustrations occupying a substantial part of the book.

PAYNE, G. L. 331

Britain's scientific and technological manpower*

Stanford: Stanford University Press. London: Oxford University Press, 1960. pp. xiii, 466. 23 × 16cm. £2 5s.

Surveys the present (1956) use of technical manpower in Great Britain, and the anticipated demand in the near and more distant future. Schools, universities and technical colleges, and the expansion of technical educational facilities and opportunities, are dealt with. There is a chapter on the research effort of the country. This book will be reviewed in a future issue.

RZIHA, E. von 621.31

Starkstromtechnik; Taschenbuch für Elektrotechniker—Band 2 (Power engineering pocket-book for electrical engineers—Vol. 2). **8th edition**

Berlin: Wilhelm Ernst, 1960. pp. 578. 21 × 15cm. £6 4s. 6d.

WOLF, M. (*Editor*) 621.311.003

Enzyklopädie der Energiewirtschaft—Band 2. Belastungskurven und Dauerlinien in der elektrischen Energiewirtschaft (Encyclopaedia of power economy—Vol. 2. Load curves and load duration curves in electrical power economy)

Berlin: Springer-Verlag, 1959. pp. xxvii, 563. 25·5 × 17·5cm. £8 6s. 8d.

SPOONER, D. F., and GRINSTED, W. H. 51

Mathematics for telecommunications and electrical engineering—Vol. 2*

London: English Universities Press, 1960. pp. xiv, 514. 19 × 12·5cm. 15s.

An introduction to mathematics suitable for first-year students embarking on City and Guilds and National Certificate courses in engineering subjects.

OTHER PUBLICATIONS

AUTOMATIC TELEPHONE AND ELECTRIC CO.

Automatic telex system. Engineering Bulletin 527. Issue 1

London and Liverpool: Automatic Telephone and Electric Co., 1960. pp. 44. 27·5 × 21cm. n.p.

Mosaic diagrams. Engineering Bulletin 2308. Issue 5

London and Liverpool: Automatic Telephone and Electric Co., 1960. pp. 15. 27·5 × 21cm. n.p.

BRITISH BROADCASTING CORPORATION

Television field trials of 405-line and 625-line systems in the u.h.f. and v.h.f. bands 1957–8

London: B.B.C., 1960. pp. 152. 28 × 22cm. £1

Film processing and after-processing treatment of 16-mm films by L. J. Wheeler. Engineering Monograph 30

London: B.B.C., 1960. pp. 19. 28 × 22cm. 5s.

INSTITUTION OF POST OFFICE ELECTRICAL ENGINEERS

Sorting letters by machine by G. P. Copping and H. J. Langton. Paper 216

London: Institution of Post Office Electrical Engineers, 1959. pp. 31. 27·5 × 21cm. 2s. 6d.

INTERNATIONAL UNION OF PURE AND APPLIED PHYSICS

Solid state physics in electronics and telecommunications—Vols. 1 and 2. Semiconductors—Parts 1 and 2. Vol. 3. Magnetic and optical properties—Part 1. Proceedings of an international conference held in Brussels, 2nd–7th June 1958, edited by M. Désirant and J. L. Michiels

London and New York: Academic Press, 1960. Vol. 1, pp. xxiii, 638. Vol. 2, pp. xvii, 639–1284. Vol. 3, pp. xvi, 557. 25·5×16cm. £17 3s. 6d. 3 vols.

STANDARD TELEPHONES AND CABLES LTD.

D.C. to d.c. transistorized converters by R. A. Holme. Application Report MK/143

Footscray, Kent: Standard Telephones and Cables Ltd., Transistor Division, 1960. pp. 46. 21 × 14·5cm. n.p.

Binary counting circuits using alloy junction transistors by R. H. Chilton. Application Report MK/144

Footscray, Kent: Standard Telephones and Cables Ltd., Transistor Division, 1960. pp. 44. 21 × 14·5cm. n.p.

UNITED NATIONS
ECONOMIC COMMISSION FOR EUROPE

The electric power situation in Europe in 1958–59 and its future prospects

Geneva: United Nations, 1960. pp. 104. 28 × 22cm. 5s.

INTERNATIONAL TELEGRAPH AND TELEPHONE CONSULTATIVE COMMITTEE—MAINTENANCE STUDY GROUP

Vocabulary of basic terms used in line transmission

Geneva: International Telecommunication Union, 1959. pp. 108. 22·5 × 32cm. n.p.

UNITED NATIONS EDUCATIONAL, SCIENTIFIC, AND CULTURAL ORGANIZATION

Information processing. Proceedings of the international conference on information processing, Unesco, Paris, 15th–20th June 1959

Paris: Unesco. Munich: R. Oldenbourg. London: Butterworth, 1960. pp. 520. 30 × 21cm. £7 7s.

Elections and transfers

The following elections and transfers approved by the Council of The Institution are effective from the 12th August 1960

ELECTIONS

Graduates

ANNING, Michael John, B.SC.(ENG.)
BARBER, Ralph Jessee
BAUGH, Horace Douglas
BISWAS, Kali Krishna, D.F.H.
BOLITHO, Simon Morgan, B.A.
BRADSTREET, Derek William George
CHERRY, Edward Moore, M.SC.
FLINT, Rex
FRIDAY, Robert Brian George
GILLON, Norman Harold, B.SC., B.ENG.
GOODMAN, John Oliver
GRIFFIN, Antony Wilfred James, B.SC.
HUME, George Alan
JONES, George Brian, DIP.TECH.(ENG.)
LAMBETH, John Stanley
MORONEY, Michael Brendan, B.E.
MULLINS, Bryan, B.SC.
PLATTS, Geoffrey Carter, B.SC.
SALEEBA, Graeme Joclen, B.E.E.
SKINNER, Michael Allen, DIP.TECH.(ENG.)
TAN, Poh Keat, B.E.
TERRY, Ronald Derek George
VANN, Anthony Leslie, B.A.
YEOMANS, Richard Millett

Students

AIR, Dennis Charles
ARTHANAYAKE, Ratnayake Harischandra Tilakasiri Jayasinghe
BAPAT, Prabhakar Ramchandra, B.E.
BHAGWAT, Anilkumar Gopalrao
BRENNAN, Edward Desmond
CHAKRAVORTY, Asit Chandra, B.E.
CHAPMAN, Christopher Paul
DAVISON, Robert Albert
DE, Bimal Bikash
DEAN, Michael
DYMOTT, John Robert
ELKINS, Michael John
ELKINS, Trevor Llewellyn
FAIRBAIRN, Kenneth
FERNANDO, Andrew Denis Nicomede
FINCH, Brian John
GANESALINGAM, Kandiah
GOH, John Tiong Ean
GOODEY, David Charles
GRIFFITHS, Gordon
GUNARATNAM, Visuvalingam
HANCOCK, Brent Sidney
HODGSON, John Michael James
HORDELL, Anthony Joseph
HORNE, Bryan William
HUSSEIN, Wan Endut
JABBAL, Hindpal Singh
JAVAID, Mohammad Tahir, B.SC.(ENG.)
JEYARASASINGAM, Kanagaratnam
JONES, Godfrey Lynn
KELLY, Jeffrey Michael
KENDALL, Barry John
KERR, Andrew
KREVELD, Philip
LAIDLER, James
LONGSTAFF, Ian Dennis
MAALAWANA, Jagath
MANNANI, Pyrali Rashid
MEHTA, Pravin Chandra Shantilal
MICHIE, Ronald McDonald
MORGAN, Brian Arthur
NIX, Peter Alan
NOSWORTHY, Kenneth William
PLUCK, Mervyn Mark
POULTER, John David
PRICE, Christopher Douglas Edward
RATCLIFFE, Peter Reginald
SALEEM, Muhammad Abdul Qadir
SAMARASINGHE, Stanley Dayaratne
SEARLE, Clive Eugene, B.SC.
SHAW, James
SIMONSEN, Leif
SINGH, Harcharan
SOMARATNE, Dippitigala Hewage Diamond
SOOD, Pramod Kumar
STOKES, Geoffrey Walter
SUMMERSCALES, Ernest
SUTHERLAND, Richard Ian Happer
SWAMPILLAI, Christy Edward Selvanayagam
THAVENTHIRAN, Kandiah
THOMAS, Pauline Elizabeth
THURAISINGAM, Nadarjah
TURTON, Neville
WALL, Terence Richard
WANIGASEKERA, Bandula
WHITE, Eric Simpson
WICKRAMARACHI, Prasanna Kumar
WILSON, William James
WOODCOCK, Terence Keith
YARNOLD, Robert John
YATAWARA, Chandrasoma Dayarathne
YOUNG, Henry John

TRANSFERS

Student to Graduate

ADJODAH, Shad Mukhlall, B.SC.(ENG.)
AGARWAL, Hari Mohan, B.SC.
AMES, Gerald Edward
ANDERSON, John Mowat, B.SC.
AULT, Maurice Peter
BAKER, Michael Herbert, B.A.
BEATON, Ian James, A.H.-W.C.
BETHEL, Peter Ivan, B.SC.
BHATTACHARYYA, Charu Krishna, B.SC.
BONNICK, Arthur Sidney
CAMPBELL, John, B.SC.
CLARIDGE, Geoffrey David, B.SC.
CLEMENTSON, Christopher Stephen, B.SC.(ENG.)
CUDDEFORD, Robin Clive, B.SC.(ENG.)
D'ANDRADE, Jayme Henry, B.SC.
DODDS, Ian Matthews, B.SC.
FERGUSON, John Alexander, B.SC.
GASKELL, Colin Simister, B.SC.
GERMAN, George David
HEATON, James Martin, B.SC.(ENG.)
HILDER, Richard Ian, B.SC.(ENG.)
HUGHES, Brian Patrick, B.SC.
KING, Robert Eric, PH.D., M.SC., B.SC.
LIDGEY, Stephen Matthew Ivan, B.SC.
LIM, Khaik Keong, B.SC.(ENG.)
MCINNES, Peter Alec, B.ENG.
MCNEILL, Anthony John, B.SC.
MICHAEL, Barry Danby, B.SC.(ENG.)
MILLEN, Royston James, DIP.TECH.(ENG.)
PUNSHI, Romesh Chander, B.A., B.SC.
RITCHIE, Peter William, B.SC.
RUTTER, Thomas Clifford
SMITH, Ian McKenzie, B.SC.
SPACKMAN, Michael Brian
STELLAKIS, Constantinos Aristodemou
STENTIFORD, Cecil Guy, DIP.TECH.(ENG.)
STEVENS, Alan James, B.SC.(ENG.)
STRINGER, Peter Edwin, B.ENG.
STUART, Peter Masson, B.SC.
VARMA, Moolraj, B.SC.
WADDELL, Michael, B.SC.
WILSON, Robert, A.H.-W.C.
WOOLLONS, David John, B.SC.

The following elections and transfers approved by the Council of The Institution are effective from the 1st September 1960

ELECTIONS

Member

LAMM, August Uno, DR.TEKN.

Associate Members

ABU-EID, Zaki Hafiz, B.SC.(ENG.)
ALLIN, Philip Edgar Varnham, M.A.
BAILEY, Sydney Breedon, M.SC.(ENG.)
BAXTER, James Gibson
BEAR, Herbert
BROOK, Roy, B.SC.(ENG.)
BURDETT, Paul Anthony, M.SC.TECH.
CROOK, Ronald Charles, B.SC.(ENG.)
DAVIDSON, Raymond
DORLING, Lynden Graham, B.SC.(ENG.)
DU PREEZ, Pieter Johannes Jacobus, B.SC.(ENG.)
EVANS, Bernard
GILHAM, Robert Thomas
HATTON, Russell Lewis Almond, B.SC.(ENG.)
HIGGINBOTTOM, Lt. John, M.A., R.N.
HOUSELEY, Philip John, B.SC.
HOWARD-JONES, Maj.-Gen. Leonard Hamilton, C.B., C.B.E., B.SC.(ENG.)
JEROME, Philip John
JINMAN, Michael, B.SC.
JOHNSON, Gregory Joseph, M.SC.
KAO, Kwan-Chi, B.SC.(ENG.), M.S., PH.D.
KRASTEV, Peter, DIPL.-ING.
LAUDER, Robert Paterson Falconer, B.SC.
LEE, John
LLEWELLYN, Lt.-Col. Alfred Howard Drake, R. SIGNALS
MCCARTHY, John Gerald
MICHEL-SMITH, John Eugene Percival, B.SC.(ENG.)
MOSELEY, Edward
RAO, Tekumalla Setumadhava, B.SC., B.E.E., PH.D.
RAWLING, Harold Simpson, B.SC.(ENG.)
ROBERTS, William Edward, B.SC.(ENG.)
ROZENSTEIN, Solomon
SAVASTANO, George
SHARMA, Mahan Dev
TAYLOR, John Dineen, B.A.SC.
WATTS, William Harold, B.ENG.
WAY, Herbert Cyril
WEBB, Alan Arthur, B.SC.
WILLIS, Kenneth Edmund Victor, B.SC.
WRIGHT, Raymond William Henry, PH.D., B.SC.

Associates

BALCOMBE, Francis Graham
BENSON, Francis William, M.B.E.
BRADSHAW, Harry Osborne
BULLIONS, Andrew John Scott
FINCHETT, Herbert Gerald
HADLEY, Hubert Kenneth
HARDMAN, Jack
LANDSBERT, Reginald Ernest
MORRIS, Islwyn
READER, Charles Leslie
SIMPSON, John Ernest
STOODLEY, William Joseph
WARWICK, Cyril Morgan

TRANSFERS

Associate Member to Member

BAKER, William Percival, B.SC.(ENG.)
BARDENS, Arthur Thomas Bertram
BARNARD, John Henry
BELL, Albert Geoffrey Robson
BOSWORTH, George Simms, M.A.
BUGDEN, George Philip, M.A.
CALDERWOOD, James Henry, M.ENG., PH.D.
CALVERLEY, Henry Bolton, B.SC.(ENG.)
CARLISLE, Samuel Skipton, M.SC.
CAWSEY, Alfred John
CLEMENT, Leslie Frank, M.B.E.
COOKE, Henry Peter, B.SC.(ENG.)
DAIN, John, M.A.
HEPPELL, Hugh Kenneth, M.ENG.
HIGGS, Victor Alexander, B.SC.
HOWARD, Peter Reuben, PH.D., B.SC.(ENG.)

Elections and transfers (continued)

Associate Member to Member (continued)

KENNEDY, Andrew Cecil
KINSMAN, Albert Reginald, B.SC.(ENG.)
LAKE, Richard Arthur, B.SC.
LAWRENCE, John Albert
LONG, Robert Rivett, B.E.E.
McDONALD, John Rankine, B.SC.(ENG.)
MEDLOCK, Reginald Stuart, B.SC.
MURISON, Robert Rae, B.SC.
NEILSON, James Meyrick, D.F.H.
OSBORN, Peter Digby, B.SC.(ENG.)
PILFOLD, Charles William
RICHTER, Alexander Nevil, M.A., M.ING.
SLADE, George Frederick, B.SC.
SMITH, Charles Eric, B.SC.(ENG.)
TERRY, John, T.D.
WATSON, Sylvester Neville
WISHART, John
WORSWICK, Thomas, M.SC.

Graduate to Associate Member

AHERN, Sean Alan, PH.D., B.SC.
ANDERSON, Charles Neil
ANDERSON, John Richard
ANDREWS, David
ARMITAGE, Norman
AYLESBURY, Nigel Lester, B.SC.(ENG.)
BAILEY, George William
BARNICOAT, Kenneth George
BEANLAND, Charles John
BEKHOR, Albert Ezra, D.F.H.
BENNETT, Alan John, B.SC.(ENG.)
BENNETT, Geoffrey Frank
BINKS, Ronald
BOICE, Capt. Cyril John, R.E.M.E.
BOLTON, Kenneth George William
BOND, John Philip, B.SC.
BOWER, Anthony Hugh Brian, M.A.
BOWER, Leslie George
BROMLEY, John Pearson, B.SC.(ENG.)
BROWNLEE, William, B.SC.
BURBIDGE, Raymond Frederick, B.SC., PH.D.
BURRIN, Eric Darvell, B.SC.(ENG.)
CALVIOU, John Henry, M.A.
CAMM, Kenneth Reginald
CAMPLING, Allen Charles
CANNAN, Norman Frederick
CAULTON, Bernard
CHAPPELOW, Brian Frederick
CHARLTON, William Henderson
CHIJIOKE, Mark Okoro, B.SC.(ENG.), PH.D.
CLARKE, Henry
COLLINS, Derek Norman
COOPER, Bernard John, B.SC.(ENG.)
COOPER, David Robin
COWIE, William Cullen Addison
CRAICK, William, B.SC.
CRAIG, Douglas Millar, A.R.T.C.
CRAIG, Joseph Andrew Catherwood, B.SC.
CRAWSHAW, Harry, B.SC.
CROSBY, Robert George, B.SC.
CULLITY, Michael John, B.E.
DANNATT, Peter Conrad, B.A.
DAVEY, David Victor
DAWSON, Derek Pearson, B.SC.(ENG.)
DEAKIN, Trevor Hugh Guy
DEELEY, Edward Mountford, B.SC., PH.D.
EASTAUGH, Denys James, B.SC.(ENG.)
ELIAS, Reginald Stuart, B.SC.
ENGLISH, Brian Box, B.SC.
EVENDEN, John, M.A., B.SC.(ENG.)
FENNER, Norman George Herbert
FLETCHER, Stephen Baldwin Dunwich, B.SC.(ENG.)
FORREST, Robert Alan
FOX, Brinley Eric, B.SC.
FREEMAN, Peter John
FROST, William Thomas
GARDNER, John Reginald
GILL, Ronald Yaxley
GLEGHORN, Peter, B.SC.(ENG.)
GOAD, Jack Sidney
GOLDFINCH, William John, B.SC.(ENG.)
GREEN, Leonard Andrew
GRITTON, John William
HALE, Jack, B.SC.(ENG.)
HARRIS, Peter Langridge, B.SC.
HEIGHINGTON, Gordon
HILL, Kenneth Albert
HILLS, Ernest William
HILYER, Gerald Robert
HODGES, Nigel William, B.SC.
HOLDEN, Stanley
HOUSE, Patrick Dennis, B.SC.
JOHNSON, Maurice William, B.E.
JONES, Glyn, B.SC.
JONES, Leonard James
KENNEDY, Joseph Mary Francis
KIDD, George
KIRBY, Lt.-Cmdr. Jack, R.N.
KIRBY, John
LAMB, Cedric St. John, B.E.
LANE, Richard Quiller
LAVIN, Peter Michael
LILLEY, Brian, B.SC.
LINDLEY, Maurice
LINSLEY, Frank
LOGUE, Hugh
LONSDALE, John Geoffrey
LOWE, Douglas Lionel Colin
LOWY, Henry
LYON, Peter Allwel
McCUTCHAN, John Charles, B.E.E.
McDONALD, John George, B.SC.(ENG.)
MACDONALD, Roderick Duncan, M.SC.
McEVOY, Maurice
MACLEOD, Malcolm, B.SC.(ENG.)
MARGARY, Aubyn Raphael, M.A.
MARSH, Bryan
MEDERER, Raymond, B.SC.(ENG.)
MERRETT, Dennis John, B.SC.(ENG.)
MIDDLETON, John Francis, B.SC.(ENG.)
MOGFORD, Glyn Thomas
MOLE, Robert Eric, B.SC.
MOUND, Allan Charles
MUFF, Norman Dennis
MUTTIAH, Eliathamby
NASHED, Ramses, B.SC.
NASSAR, Walter Nicolas
NEWMAN, Michael Harvey, B.SC.
NEWMAN, Reginald William
NIMMO, Robert Dick, B.SC.
NURSE, Michael John Dennant
OGDEN, Dennis, B.SC.TECH.
PAGE, Roy James
PALMER, Peter Wedgeberry
PEARSON, Robert Henry, B.SC.(ENG.)
PEART, Alan Thomas
PEDLEY, Thomas Read
PERRIN, Neill Hicks, B.SC.(ENG.)
PICKFORD, Stanley George
POPPLEWELL, John Arnold
POVEY, John Arthur
PRICE, Derek Alfred Charles
PRICE, James Ruston
PYE, Tristram Robert, B.SC.(ENG.)
RABY, Norman, B.SC.
RAMACHANDRAN, Peruvemba Nanuaiyer
REDMOND, Stanley
REED, Geoffrey Alexander Leslie, B.SC.
RHODES, Gerald Dawson, B.SC.(ENG.)
RUSSELL, Bertram Cyril, B.ENG.
SALT, Kenneth John
SALVAGE, David Laurence, B.SC.(ENG.)
SANKEY, Gordon
SCHWENK, Albert Frank Basil
SELLERS, Norman, M.SC.
SHARP, Jack Burgess
SHEARDOWN, George Alan
SHIRLEY, Maj. Eric Edward, R.E.M.E.
SIMMONITE, Thomas John
SMITH, Eric
SMITH, John Frederick, B.SC.(ENG.)
SMITH, Stanley James Gordon
SMITH, Stanley Terence
SPEDDING, Roger William
STARTIN, Richard Clive
STEPHEN, Kenneth
STEVENSON, Ian Russell, B.SC., B.E.
STREATFIELD, Geoffrey Alan
STYLES, Gerald Milson, B.SC.(ENG.)
SYKES, Neil Winn, M.A., B.SC.(ENG.)
TARNER, Henry Charles James
TEAGUE, Bryan Thomas, B.SC.
TELFORD, Michael, B.SC.
THAMBIRATNAM, Ratnasingham Emmanuel, B.SC.
THOMAS, David, B.SC.(ENG.)
THOMAS, Roy George
TOMICA, Alojzy, B.SC.(ENG.)
TUFNELL, John Edgar
UNSWORTH, John Joseph
VICKERS, Kenneth Lee
WALKER, Alan John
WALKER, John Montgomery
WALLIS, George Alan
WALLIS, Keith
WARD, John Noel Harvey, B.SC.
WARNER, Allen George
WELLS, George William, M.E.E., B.SC.(ENG.)
WESTMORE, John Reginald, D.F.H.
WICKHAM, Alan Stanford
WILLIS, John, B.SC.
WITHERS, Owen Roy, D.F.H.
WOLSKI, Ryszard, B.SC.(ENG.)
WOOD, Peter
YOUNG, John Stewart, B.SC.(ENG.)

Student to Associate Member

CLARK, Laurence George Stanley, B.SC.

District Meetings

ARRANGEMENTS for District Meetings in October and November 1960 other than in the area of a local Centre

October 1960

OXFORD (at the District Office of the Southern Electricity Board, 37 George Street at 7 p.m.)

12 *Wednesday* P. BOWLES, M.SC. 'Some engineering problems on Nimrod'

November 1960

OXFORD (at the District Office of the Southern Electricity Board, 37 George Street at 7 p.m.)

9 *Wednesday* V. G. NEWMAN, B.SC.(ENG.) 'Pumped storage'

British Nuclear Energy Conference

DETAILS of four forthcoming meetings of the British Nuclear Energy Conference are given below. Tickets of admission are not required. Papers and discussions on the applications of nuclear energy and ancillary subjects are published in the quarterly *Journal of the British Nuclear Energy Conference*. The annual subscription payable by members of The Institution who wish to receive the *Journal of the B.N.E.C.* regularly is 30s. post-free. Single copies are available at 7s. 6d. each

1960

OCTOBER 12 *Wednesday* (6 p.m.)

Sponsoring society and place of meeting: The Institution of Mechanical Engineers, 1 Birdcage Walk, London S.W.1

INSPECTION OF NUCLEAR POWER PLANT Lecture by H. N. Pemberton

OCTOBER 25 *Tuesday* (5.30 p.m.)

Sponsoring society: The Joint Panel on Nuclear Marine Propulsion
Place of meeting: The Institute of Marine Engineers, Memorial Building, 76 Mark Lane, London E.C.3

SOME OBSERVATIONS ON THE DESIGN AND CONSTRUCTION OF THE N.S. *SAVANNAH* J. A. Dodd and S. Macdonald

NOVEMBER 8 *Tuesday* (5.30 p.m.)

Sponsoring society and place of meeting: The Institution of Civil Engineers, 1–7 Great George Street, London S.W.1

SOME CONTRIBUTIONS FROM NUCLEAR POWER TO ENGINEERING PRACTICE I. Davidson

NOVEMBER 9–10 *Wednesday–Thursday*

Sponsoring society and place of meeting: The Institution of Mechanical Engineers, 1 Birdcage Walk, London S.W.1

SYMPOSIUM ON THE USE OF SECONDARY SURFACES FOR HEAT TRANSFER WITH CLEAN GASES

Information on the papers to be presented at the symposium will be published in the October 1960 issue of the *Journal of the B.N.E.C.* Further details may be obtained from the Secretary of The Institution of Mechanical Engineers

ANNOUNCEMENTS TO MEMBERS

THE HOMES FUND

SUMMARY OF CONTRIBUTIONS RECEIVED TO 9TH AUGUST 1960

	no. of contributors	£	*s.*	*d.*
£1000 and over	8	8685	0	0
£100 to <£1000	32	7181	3	0
£5 to <£100	922	9634	9	7
£2 to <£5	2277	6286	19	9
under £2	29045	15274	1	5
		47061	13	9

HONOURS AND DISTINCTIONS CONFERRED ON MEMBERS

IT is regretted that, in the list of members of The Institution who were included in the Birthday Honours and Distinctions conferred by Her Majesty the Queen (July 1960 *Journal*, p. 454), the name of Mr. G. W. A. Birkett, MEMBER, was omitted. He was appointed a Commander of the Most Excellent Order of the British Empire.

PROGRAMME OF MEETINGS

SESSION 1960–61

THE programme card of London meetings for the first half of the session is being sent with this issue of the *Journal* to all members not residing within the area of a local Centre or Sub-Centre.

Any member living in the Provinces who often visits London, and is thus able to attend London meetings, may obtain a copy of the London card on application to the Secretary of The Institution.

MEMBERS' GUESTS

MEMBERS are reminded that, under the Bye-laws of The Institution, every member (Students excepted) is entitled to introduce one visitor at each Ordinary Meeting. By direction of the Council, this also applies to all meetings of the Electronics and Communications, Measurement and Control, Supply, and Utilization Sections and to Informal Meetings.

DISCUSSIONS AT MEETINGS

THE Council of The Institution desire it to be understood that contributions to discussions at meetings should not be read from manuscript, since they consider that this form of presentation is contrary to the true spirit of a discussion.

WRITTEN CONTRIBUTIONS TO DISCUSSIONS

MEMBERS who are unable to be present at a meeting at which a paper is read, or who if present do not have an opportunity of speaking, may submit written contributions to the discussion, which will be considered for publication in the *Proceedings* of The Institution.

Written contributions on papers published in the *Proceedings* without being read at meetings will also be considered for publication.

Members should note that the Papers Committee have been obliged to set a limit of 300 words for contributions of either sort.

NORTH-EASTERN CENTRE DIAMOND JUBILEE BOOKLET

TO commemorate the Diamond Jubilee of their foundation, the North-Eastern Centre of The Institution have produced a Diamond Jubilee Booklet. It contains the full text of the Diamond Jubilee Address 'Their achievement—our heritage', delivered by Mr. J. R. Beard to the Centre on the 14th December 1959, which traces the history of the electrical engineering achievements of the North-East Coast, particularly in the fields of electric power supply and traction. Full information is also given on the various Centre Committees.

A limited number of copies of the booklet are available for members outside the North-Eastern Centre, who should apply to the Honorary Secretary of the Centre, Mr. R. Bruce, C. A. Parsons and Co. Ltd., Heaton Works, Newcastle upon Tyne 6.

JOINT BRITISH COMMITTEE FOR STRESS ANALYSIS

A JOINT British Committee for Stress Analysis has been set up in Great Britain. It will represent the interests of this country in the field of stress analysis at the periodical meetings of the Permanent Committee which are held in Europe and will thus ensure adequate British participation in international conferences on the topic. The Permanent Committee, membership of which is open to all Western European countries, aims to encourage international collaboration in the sphere of stress analysis, and to this end will arrange international conferences at four-year intervals, normally phased with the International Congresses on Applied Mechanics. The officials and secretariat of the Permanent Committee will usually be appointed by the National Committee in whose country the next international conference is to be held.

The Joint British Committee will act in the collective interests of the constituent bodies by maintaining liaison with the Permanent Committee for European or International Conferences on Stress Analysis and with oversea societies and institutions concerned with the subject.

The British Committee consists of representatives appointed by The Royal Aeronautical Society, The Institution of Civil Engineers, The Institution of Electrical Engineers, The Institute of Marine Engineers, The Institution of Mechanical Engineers, The Royal Institution of Naval Architects, The Institute of Physics and The Physical Society, The Institution of Structural Engineers, and The Institute of Welding. Mr.

A. F. C. Brown, the representative of The Institution of Mechanical Engineers, has been elected the first Chairman of the British Committee, and The Institution of Mechanical Engineers provides the secretariat.

SYMPOSIUM ON ELECTRICAL CONTACTS

A SYMPOSIUM on electrical contacts, at Brunel College of Technology, London, from the 5th to 7th April 1961, is being arranged by The Institute of Physics and The Physical Society in collaboration with The Institution.

The symposium will cover recent advances in the study of the phenomena occurring at mating surfaces carrying currents used in light electrical engineering. It will embrace electrical erosion and material transfer, mechanical wear, and the influence of surface films and contamination and will deal with make-and-break contacts, sliding contacts, semi-permanent contacts and connections, between metallic and non-metallic materials. The major interest will be in contact resistance.

The symposium is intended mainly for persons concerned with the design and improvement of contacts. There will be a small informal exhibition, which will be open during the symposium to those attending the meetings. Abstracts, but not preprints, will be circulated before the symposium, the proceedings of which will not be published in full.

Further information may be obtained from the Secretary, The Institute of Physics and The Physical Society, 47 Belgrave Square, London, S.W.1.

SYMPOSIUM ON AUTOMATIC CONTROL

THE 29 British papers contributed to the first international congress of the International Federation of Automatic Control, held in Moscow from the 27th June to 7th July 1960, will be discussed at a symposium in London on the 27th and 28th September 1960. The symposium is sponsored by the British Conference on Automation and Computation and arranged by The Institution of Mechanical Engineers.

Preprints of the papers are available and will be supplied to those registered to attend the symposium. A list of the papers, together with a registration form, may be obtained from the Secretary of The Institution of Mechanical Engineers, 1 Birdcage Walk, London S.W.1.

OPTICAL INSTRUMENTS AND TECHNIQUES

A CONFERENCE on optical instruments and techniques, being arranged by the British National Committee for Physics, under the auspices of the International Commission for Optics, will be held in London from the 10th to 14th July 1961.

Further information may be obtained from Mr. K. J. Habell, National Physical Laboratory, Teddington, Middlesex.

WORLD POWER CONFERENCE

SIXTH PLENARY MEETING, MELBOURNE, 20TH–26TH OCTOBER 1962

THE technical programme of the Sixth (Plenary) World Power Conference has been issued by the Australian National Committee. The theme of the conference will be 'The changing pattern of power'.

The five divisions of the conference will deal with energy resources; the production and amelioration of primary sources of energy; transformation of primary to secondary energy, and transportation of energy; utilization of primary and secondary energy; and economic evaluation of alternative energy sources.

Arrangements for the preparation of the papers to be presented by the British National Committee are in the hands of a special papers committee. Any suggestions as to papers should be sent to the Secretary, British National Committee, World Power Conference, 201 Grand Buildings, Trafalgar Square, London W.C.2.

Papers must not have been published previously, must not contain remarks derogatory of another country and must not contain advertising material. English and French have been adopted as the working languages for the meeting.

COURSES IN HIGHER TECHNOLOGY

THE London and Home Counties Regional Advisory Council for Technological Education have published a bulletin of special courses in higher technology, including management studies and commerce, for the autumn term 1960–61. These courses do not regularly appear in college calendars or prospectuses as part of a grouped course or as subjects offered for endorsement on Higher National Certificates.

They are normally part-time (usually evening) courses, but full-time courses, which are specially arranged and not of more than three months' duration, are also included. The bulletin may be obtained from the Secretary, Regional Advisory Council, Tavistock House South, Tavistock Square, London W.C.1, price 3s. 6d. post-free.

ELECTRON DEVICES

A MEETING on electron devices at the Shoreham Hotel, Washington, D.C., U.S.A., on the 27th and 28th October 1960 will discuss recent advances in integrated and functional devices, new materials and techniques for fabricating conventional transistors of improved performance, and device reliability.

The meeting is being organized by the Professional Group on Electron Devices of the Institute of Radio Engineers, and further information may be obtained from the Chairman of the General Committee, Dr. J. A. Hornbeck, Bell Telephone Laboratories, Murray Hill, N.J., U.S.A.

COMPUTER CONFERENCE

THE tenth annual Eastern Joint Computer Conference will be held in New York from the 13th to 15th December 1960 at the Hotel New Yorker and the Manhattan Center. It will deal with recent achievements and techniques in the design and use of computing equipment.

The conference is sponsored by the National Joint Computer Committee, consisting of representatives of the Institute of Radio Engineers, the American Institute of Electrical Engineers, and the Association for Computing Machinery. Further information may be obtained from the Technical

Programme Chairman, Mr. E. C. Kubie, Computer Usage Co. Inc., 18 East 41st Street, New York 17, N.Y., U.S.A.

Forthcoming events at Savoy Place

ALL meetings are held at Savoy Place, beginning at 5.30 p.m. (tea at 5 p.m.) except where otherwise stated. The nature of the meeting is indicated by the following key:

ED EDUCATION DISCUSSION CIRCLE
E ELECTRONICS AND COMMUNICATIONS SECTION
M MEASUREMENT AND CONTROL SECTION
MED MEDICAL ELECTRONICS DISCUSSION GROUP
O ORDINARY
S SUPPLY SECTION
U UTILIZATION SECTION

After each paper that has now been published is added the month when a synopsis appeared in the *Journal* under 'Papers and monographs published individually this month', i.e. about the time when the paper was published as a separate. A paper that has not yet been published will be available at least ten days before the meeting at which it will be read. The full list of London meetings is given in the meetings card

October 1960

O **6** *Thursday* SIR HAMISH D. MACLAREN, K.B.E., C.B., D.F.C.*, LL.D., B.SC. Inaugural Address as President‡

MED **7** *Friday* O. C. J. LIPPOLD, M.B., B.S., *and* D. R. WILKIE, M.D., M.B., B.S., M.R.C.P., will open a discussion on 'Nerve endings'† (at 6 p.m., tea at 5.30 p.m.)

M **11** *Tuesday* C. G. GARTON. Chairman's Address 'Time and insulation'‡

ED **12** *Wednesday* P. F. SOPER, PH.D., B.SC.(ENG.), will open a discussion on 'Laboratory work for the Part III Examination'† (at 6 p.m., tea at 5.30 p.m.)

U **13** *Thursday* J. M. FERGUSON, B.SC.(ENG.). Chairman's Address 'Developments in electrical plant for industry'‡

S **19** *Wednesday* J. E. L. ROBINSON, M.SC. Chairman's Address 'The developing engineer'‡

M **25** *Tuesday* E. H. COOKE-YARBOROUGH, M.A., *and* R. C. M. BARNES, B.SC.(ENG.) 'Rapid methods for ascertaining whether the activity of a weak radioactive sample exceeds a predetermined level' (paper 3258M) *synopsis:* July 1960

E **26** *Wednesday* T. B. D. TERRONI, B.SC. Chairman's Address 'Channelling—a sketch'‡

O **27** *Thursday* A. HEWISH, M.A., PH.D. Lecture on 'The principles and operation of large radio telescopes'‡

† No advance information will be available and no Press report will be permitted
‡ No advance information will be available

Contents of the current *Proceedings*

The date in italics is that of the Journal review, special article, or synopsis. Where given, the date in capitals is the month in which a paper or monograph was published individually

PART A. POWER ENGINEERING (AUGUST 1960)

See the Journal for August 1960, p. 507

PART B. ELECTRONIC AND COMMUNICATION ENGINEERING (SEPTEMBER 1960)

PROF. C. F. POWELL, M.A., PH.D., SC.D., F.R.S. PAPER 3301 The Fifty-First Kelvin Lecture on **Cosmic radiation** *May 1960*

R. W. A. SCARR, B.SC.(ENG.), PH.D., *and* R. A. SETTERINGTON, B.SC. PAPER 3176M, JANUARY 1960 **Thermistors, their theory, manufacture and application** *September 1960*

Communication on **An analogy between non-linear resistive and linear a.c. networks** by D. Q. Mayne, M.SC.(ENG.)

R. V. HARVEY, B.SC. PAPER 3221E, MARCH 1960 **V.H.F. sound broadcasting** *May 1960*

R. J. HITCHCOCK, M.A., G. O. EVANS, B.SC., *and* R. NAISMITH. PAPER 3285E **Sunspot-cycle variations in the discrepancies between predicted and observed frequencies for use in radiocommunication** *July 1960*

I. LEMCO, B.SC., *and* B. ROGAL, B.SC.(ENG.). PAPER 3298E **Resistive-film milliwattmeters for the frequency bands 8·2–12·4 Gc/s, 12·4–18 Gc/s and 26·5–40 Gc/s** *September 1960*

D. J. WHYTHE, B.SC.(ENG.), *and* K. W. T. HUGHES, B.SC. PAPER 3303E **A slot-excited corner reflector for use in Band V (610–960 Mc/s)** *September 1960*

PROF. A. R. BILLINGS, B.SC., PH.D., *and* D. J. LLOYD, B.SC.(ENG.), PH.D. PAPER 3295E **A correlator employing Hall multipliers applied to the analysis of vocoder control signals** *August 1960*

K. E. RANDALL *and* F. L. WARD, B.SC. PAPER 3272E **Diffusion of sound in small rooms** *September 1960*

I. C. HUTCHEON, M.A., *and* D. SUMMERS. PAPER 3227M, MARCH 1960 **A low-drift transistor chopper-type d.c. amplifier with high gain and large dynamic range** *June 1960*

C. D. RUTTER, B.SC.(ENG.), R. D. WRIGHT, B.SC.(ENG.), R. N. ALDRICH-SMITH, M.SC., *and* E. J. R. HEWITT, M.A. PAPER 3256M **An automatic continuous denier recorder for synthetic textile yarns** *September 1960*

E. E. WARD, PH.D. PAPER 3281E **The design of controlled rectifiers using triode transistors** *July 1960*

H. N. DAGLISH, B.SC., PH.D. PAPER 3308E **Anode luminescence in oxide-cathode receiving valves** *September 1960*

PART C. MONOGRAPHS (SEPTEMBER 1960)

JOSEPH BEN URI, DR.-ING. 354U, FEBRUARY 1960 **Life expectancy of electrical machines with variable loads** *February 1960*

I. CEDERBAUM, PH.D. 355E, FEBRUARY 1960 **Voltage and current transformation matrices** *February 1960*

E. A. FREEMAN, B.SC., PH.D. 356M, FEBRUARY 1960 **Stabilization of control systems with backlash using a high-frequency on–off loop** *February 1960*

G. H. METSON, M.C., D.SC., PH.D., M.SC., B.SC.(ENG.), *and* EDITH MACARTNEY, M.SC., B.SC. 357E, FEBRUARY 1960 **Conductivity of oxide cathodes. Part 8—Current-dependent matrix dissociation** *February 1960*

L. LEWIN. 358E, FEBRUARY 1960 **Radiation from discontinuities in stripline** *February 1960*

L. LEWIN. 359E, FEBRUARY 1960 **Some observations on waveguide coupling through medium-sized slots** *February 1960*

S. CORNBLEET, B.SC. 360E, FEBRUARY 1960 **New design method for phase-corrected reflectors at microwave frequencies** *February 1960*

J. L. DOUCE, M.SC., PH.D., *and* R. E. KING, M.SC. 361M, FEBRUARY 1960 **Effect of an additional non-linearity on the performance of torque-limited control systems subjected to random inputs** *February 1960*

E. F. F. GILLESPIE, M.ENG. 362E, FEBRUARY 1960 **Power flow and negative wave impedance in the dielectric-rod waveguide** *February 1960*

W. HERSCH, PH.D., B.SC.(ENG.). 363E, FEBRUARY 1960 **Surface-wave aerial** *February 1960*

T. E. BROADBENT, M.SC., PH.D. 364M, MARCH 1960 **Characteristics of the trigatron spark-gap at very high voltages** *March 1960*

R. KING, PH.D., *and* G. H. OWYANG, PH.D. 365E, MARCH 1960 **Experimental study of the slot aerial and the three-element collinear array of slot aerials** *March 1960*

W. E. SMITH, B.SC. 366M, MARCH 1960 **Theory of steady forces in variable-parameter networks** *March 1960*

O. P. D. CUTTERIDGE, M.SC.(ENG.), PH.D. 367M, MARCH 1960 **Further theory of a certain continued fraction** *March 1960*

B. V. JAYAWANT, PH.D., B.ENG. 368M, MARCH 1960 **Flux distribution in a permeable sheet with a hole near an edge** *March 1960*

H. F. HARMUTH, DIPL.-ING., DR.TECH. 369E, MARCH 1960 **Orthogonal codes** *March 1960*

R. F. BROWN, B.ENG. 370M, APRIL 1960 **Calculation of switching functions as a means of minimizing error in an on–off control system** *April 1960*

E. W. LEE, B.SC., PH.D. 371M, APRIL 1960 **Eddy-current effects in rectangular ferromagnetic rods** *April 1960*

J. A. BETTS, B.SC., PH.D., *and* J. P. NEWSOME, M.SC. 372M, APRIL 1960 **Investigation of an electrical non-destructive method of measuring the depth of surface hardness in flame-hardened steels** *April and September 1960*

R. A. WALDRON, M.A. 373E, APRIL 1960 **Perturbation theory of resonant cavities** *April 1960*

O. P. D. CUTTERIDGE, M.SC.(ENG.), PH.D. 374M, APRIL 1960 **Two-terminal *RC* networks and theoretically related topics** *April 1960*

O. E. MAINER, M.SC.(TECH.). 375U, APRIL 1960 **Brush contact losses due to load and parasitic currents in polyphase commutator motors** *April 1960*

T. F. MONAHAN, B.SC. 376S, APRIL 1960 **Calculation of the current in non-linear surge-current-generator circuits** *April 1960*

H. J. SCHMITT. 377E, APRIL 1960 **Transients in cylindrical antennae** *April 1960*

G. S. BROSAN, PH.D., B.SC.(ENG.). 378S, MAY 1960 **New form of the tensor equations of electrical machines** *May 1960*

P. HAMMOND, M.A. 379, MAY 1960 **Electric and magnetic images** *May 1960*

R. G. MEDHURST, B.SC. 380E, MAY 1960 **R.F. spectra of waves frequency modulated with white noise** *May 1960*

J. K. SINHA, M.SC., PH.D. 381E, MAY 1960 **Method for the evaluation of equivalent circuit parameters of an asymmetric waveguide junction** *May 1960*

J. W. CROMPTON, M.E. 382E, MAY 1960 **Design of cylindrical metal-plate microwave lenses fed by non-resonant slotted waveguide arrays** *May 1960*

R. M. HUEY, B.SC., B.E., O. PAWLOFF, DIPL.-ING., *and* T. GLUCHAROFF, DIPL.-ING., M.E. 383M, JUNE 1960 **Extension of the dual-input describing-function technique to systems containing reactive non-linearity** *June 1960*

J. C. H. DAVIS, M.A., *and* H. O. FRIEDHEIM, B.SC. 384E, JUNE 1960 **Intermodulation on amplitude-modulated multi-channel line links** *June 1960*

PROF. N. KESAVAMURTHY, M.A., B.E., M.SC.(TECH.), *and* P. K. RAJAGOPALAN, B.E., M.S., PH.D. 385U, JUNE 1960 **Equivalent circuit and evaluation of eddy-current loss in solid cores subjected to alternating and rotating magnetic fields** *June 1960*

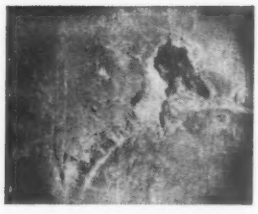
J. R. WAIT, M.A.SC., PH.D., *and* A. M. CONDA, B.A. 386E, JUNE 1960 **Resonance excitation of a corrugated-cylinder antenna** *June 1960*

Communicated discussion on **Transient response of bandpass filters to modulated signals**

LONDON REPORT

ORDINARY MEETING

FACIAL DAMAGE



On the 12th May 1960, at Savoy Place, under the chairmanship of Mr. G. S. C. Lucas, Dr. J. H. Mason presented his paper on 'The resistance of sheet insulation to surface discharges', first tracing briefly the historical aspects of work on discharge observations. (A short article based on the paper appears on p. 541.) The studies made by Brazier and Robinson on the thermal stability of cable dielectrics led to the examination of cavity and surface discharges, and a number of workers have devoted a considerable amount of research to the mechanism of discharge effects.

Experience in service demanded that methods of evaluating insulating materials by short-duration techniques should be devised; and the investigation of suitable electrode systems, conducive to giving consistent results, in controlled conditions, on a variety of sheet materials, led to the paper presented that evening. However, Dr. Mason wisely directed attention to the need for exercising caution as yet before directly interpreting the results in terms of behaviour in service.

The discussion was enlivened by a notable contribution from French visitors, including a lady obviously a 'master' of the subject. In opening, Mr. P. R. Hartshorn, while commending Dr. Mason's cautionary words, felt that the results were of real practical value. M. G. Leroy commented on the chemical degradation which the atmospheric conditions met in service could cause in combination with electric discharges, and emphasized the importance of this effect in any assessment.

Electrode form

Electrode arrangements led to much discussion, and the majority of speakers touched on the ever-fruitful topic with insulation engineers, from whom the question 'and what shape are the electrodes?' comes automatically. Mme. B. Fallou and M. G. Lang described in some detail the arrangements on which they have worked independently in France. The former had a preference for methods which cause a large area to be affected by discharges which induce uniform wear, or for a somewhat similar parallel-plate electrode system using instead a high-capacitance barrier which concentrates the stress, in a manner comparable with that of the system used by Dr. Mason.

It was claimed that these techniques enabled several different observations to be made, including loss of weight and chemical effects. The full contribution made by Mme. Fallou received warm acknowledgment. M. Lang explained a method employing spherical-ended electrodes and gave some interesting details of his measuring technique.

Mr. K. H. Stark supported Dr. Mason's approach regarding electrodes, but not his employment of circulating dry air, considering that only reasonable access to the ambient air was necessary. He felt that the thickness of material under test had an influence on the nature of the discharges, which he illustrated by slides.

An alternative approach was provided by Messrs. J. S. Simons and W. P. Baker, who both favoured the 'needle point' electrode system, claiming results comparable with those obtained by Dr. Mason; the production of these, however, had been accelerated by using higher frequencies. Mr. Simons gave an account of discharge effects on micaceous materials and described an embedded-disc-type electrode and the results found.

Effects on materials

The paper included extensive data on various materials in both sheet and film form. Glass laminates, with the various bonding agents, had received attention at ambient and elevated temperatures and in conditions of mechanical strain. Correspondingly, several contributors brought forward many points of interest, and Mr. Stark, in particular, touched on the effects of tension on epoxy–glass laminates. M. Leroy had earlier given his views on the large differences in behaviour which had been found with Samica bonded with natural and silicone resins.

Mr. Baker commented on the effect of mechanical strain and felt that the answers had yet to be found. Dr. N. Parkman immediately responded with the views held by the E.R.A., and proceeded to discuss the criticisms of accelerated tests, emphasizing that appreciation of the shortcomings of such tests in relation to service life did exist. Nevertheless, they could unquestionably provide useful guidance.

Dr. Mason, in reply, paid tribute to the work of Dr. Parkman, particularly in the associated field of resistance to tracking. He warmly welcomed the contribution by the French visitors and realized that brevity limited the extent to which the work being done in France could be explained. He considered the assessment of chemical degradation to be most interesting. He found himself unable to accept the views of Messrs. Simons and Baker regarding the electrode systems, but agreed that longer times could have been used in the frequency-accelerated tests.

Dr. Mason replied with a competence, neatness and compactness which certainly must have given satisfaction to the participants, and the full record, which will appear in Part A of the *Proceedings*, will be welcomed by interested engineers.

This was a Measurement and Control Section paper and, fittingly, Prof. A. Tustin, Chairman of the Section, moved the vote of thanks. This he performed most admirably by drawing on his own experience with electrical-machine insulation. He quasi-seriously suggested that, if all materials had been either complete insulators or complete conductors, electrical engineering might have been non-existent. In consequence, many interesting, baffling but fascinating problems would have been lost, together with the pleasure provided by Dr. Mason and his work. The motion was warmly acclaimed.

F. C. W.

BULLETIN OF THE SECTIONS

ELECTRONICS AND COMMUNICATIONS

CRYSTAL-GAZING

It is a good thing once in a while to turn from the past and to crystal-gaze into the future. The subject of the discussion meeting on 'New semiconductor devices and their possible application', held at Savoy Place on the 25th May 1960 under the guidance of Dr. A. F. Gibson and Mr. G. King, enabled this to be done in a double sense.

Since the early development work by Shockley on the transistor, an increasing amount of effort has gone into semiconductor research, and electronic-equipment designers have had to do much rethinking of circuitry and redesigning of equipment to take advantage of the improvements to be achieved by replacing their valves by semiconductor devices. Transistorization has become the catchword of the day, and transistors continue to extend their range in both frequency and power; Mr. King quoted the Bell Telephone Laboratories mesa unit oscillating up to 3000 Mc/s, and directed the attention of any power engineers present to the existence of a transistor of the controlled-rectifier type able to handle 10 kW.

Nevertheless, it seems that transistorization is by no means the end of the story; indeed it appears to be only the beginning. The study of semiconductor phenomena is opening up quite new lines of approach to help—or bedevil—the hardware designers, and has reached a point where only a few of the new devices could be dealt with by the openers of the discussion within the time allowed.

Of these possibilities, Dr. Gibson selected the Esaki, or tunnel diode, the field-effect gyrator, *p–n* junction cathodes, negative-mass amplifiers, and the application of cyclotron resonance; while Mr. King indicated some possible uses of Esaki diodes, variable-capacitance diodes, photo-resistors, thermoelectric coolers, etc.

Tunnel diodes under water

Not unnaturally, discussion centred mainly on the tunnel diode, which is now commercially available. Dr. Gibson, primarily interested in the physics of the devices, indicated that tunnel diodes could be made of a wide variety of materials but that they operated with controlled impurities five orders of magnitude greater than those to which we had become accustomed in the transistor. This has created a new interest in the technology of these very impure materials and may lead to other inventions.

Special features of the tunnel diode which make it extraordinarily interesting are its extreme suitability for operation as a two-state device with very high transition speed, its very low impedance, most valuable in conjunction with certain types of magnetic circuitry, and its relative insensitivity to environment, including insensitivity to radiation. Tunnel diodes were in fact demonstrated at the meeting, stripped of their cases and operating under water.

A great deal of discussion concerned a quotation from Esaki that the noise temperature of the tunnel diode could range from 100° to 300°K; how, it was asked, could the noise temperature be lower than the actual ambient temperature?

A spirited discussion on whether a negative resistance at temperature T produced positive or negative noise was entertaining but not entirely conclusive.

Standardization problems

Several speakers raised the general issue of how far the proliferation of new devices was a good thing: the equipment designer would often prefer to standardize on a reasonably small number of known and proved components and circuits, and the user, faced with the problem of training maintenance personnel, can feel even more strongly on this point. Countering this, Mr. King quoted past experience in the valve field, where, after the rather rigid control during the last war, the number of types had multiplied rapidly to meet the demands of users and to the embarrassment of the device makers. He believed that pressure to use the most suitable device which can be made available will in general win over excessive standardization.

In spite of the exciting possibilities of other devices held out by the openers, these did not receive a great deal of attention, although the backward rectifier came in for honourable mention. It seemed that those taking part in the discussion preferred to concentrate on the devices they might be forced to use tomorrow and to let the prospect of more and more new devices coming the day after tomorrow take care of itself.

The seating capacity of the Institution Library was fully tested by the large attendance at the meeting, which much appreciated the Chairmanship of Mr. M. J. L. Pulling and in particular the lucid way in which he summed up the discussion, including the remarks on noise temperature.

L. J. I. N.

SUPPLY

THE PROVINCIAL STORY

THE past session again saw considerable activity in the Supply Groups of the three local Centres which have them. Although more detailed accounts appear at intervals, nevertheless the collated records which the Chairmen of the Groups have provided below will give an over-all picture of the work and interests of these Groups.

North-Western Supply Group

The 1959–60 Session produced much interesting discussion, but an occasion occurred when it was made clear that The Institution must take every opportunity to impress on the younger members that discussion does not permit the reading of lengthy manuscript. The average attendance was not as high as during the previous session but attendance was numerically more consistent. All the meetings were held at the Engineers' Club, Manchester.

The first took place on the 20th October 1959, when Mr. G. B. Harper read his paper 'The selection of insulation levels and tests for high-voltage transformers'. It was attended by 61 members, and a lively discussion with much wit followed.

The meeting on the 27th November produced a specialized, or 'narrow', discussion on the paper by Dr. H. J. Walker 'Generator/motor problems in pumped-storage installations' and was attended by 49 members.

The meeting on the 26th January 1960 was of special interest. Dr. J. R. Mortlock, the Section Chairman, was present when Dr. J. S. Forrest, together with Messrs. P. J. Lambeth and D. F. Oakeshott, presented their paper on 'Research on the performance of high-voltage insulators in polluted atmospheres'. Pollution is not an unknown gremlin in the north-west, and the 63 members present contributed to an interesting discussion on a 'greasy' subject. Dr. Forrest can always be relied on to provide an enjoyable reply to any discussion.

On the 23rd February, Messrs. T. R. Manley, K. Rothwell and W. Gray read a paper on 'The application of low-pressure resins to some high-voltage switchgear designs'. The introduction of a comparatively new material had the expected effect of a record attendance, for the session, of 74. The discussion was much enjoyed, and it is of course understood that there is no advertising at Institution meetings!

The 12th April brought the last meeting of the session, when we were pleased to receive Mr. F. J. Hutchinson, the Centre Chairman, on his official visit. The paper read was 'Turbogenerator performance under exceptional operating conditions' by Mr. T. H. Mason, Dr. P. D. Aylett and Mr. F. H. Birch. The good spring weather, which can also occur in Manchester, may have been responsible for the reduced attendance of 44 members. The evening produced an interesting discussion and a pleasurable close to the 1959–60 series of papers.

A. C. E.

South Midland Supply and Utilization Group

The most encouraging features of the session were the continued increase in membership, which now stands at 727, and an increase in the average attendance at the meetings from 48 in 1958–59 to 66 in 1959–60.

Seven papers were read and discussed during the session. Three of these dealing with supply subjects and two dealing with utilization subjects were read before the Group. The two remaining papers were read before combined meetings, the first before the Group, the South Midland Centre, the South Midland Electronics and Measurement Group, and the Birmingham Centre of the Institution of Post Office Electrical Engineers, and the second before the Group and the South Midland Centre.

We were very pleased to welcome Dr. J. R. Mortlock, Chairman of the Supply Section, at the meeting on the 14th March 1960, when the paper entitled 'Turbogenerator

performance under exceptional operating conditions' was read by Mr. T. H. Mason, Dr. P. D. Aylett, and Mr. F. H. Birch. Dr. Mortlock urged members, particularly the younger ones, to take an active part in the discussions on the papers presented.

The Group was also honoured with a visit by Mr. T. E. Houghton, Chairman of the Utilization Section, on the 8th February, when a paper entitled 'Discrimination between h.r.c. fuses' was given by Mr. E. Jacks. E. V. H.

Western Supply Group

The activities of the Group have been very successful during the 1959–60 Session, both in the attendance and quality of discussions at the meetings and in the social functions which have occurred.

The autumn visit took place on the 3rd October 1959 and was very well supported by members and their ladies. Those from the north side of the Bristol Channel travelled by train and coach to meet their colleagues from the south side at Avonmouth Docks, where a very instructive and interesting inspection was made of the installation, reminding many visitors of the importance of these docks, and the modernization, particularly from an electrical point of view, which was taking place.

A very enjoyable luncheon was taken in Bristol as guests of the Port of Bristol Authority. After lunch a visit was made to Berkeley Castle, which although normally closed at that time of year had been specially opened for the party at the request of the organizing committee. Berkeley Castle was of great historical interest, and the organizing committee felt that in their selection of places to visit due consideration had been given to matters of general interest; this was no doubt appreciated by the ladies.

The meetings of the Group have been particularly successful, with an average attendance of 76, which is higher than in previous years. We were particularly fortunate in having a number of papers presented by our own members of the Western Centre, and we were gratified that one of these meetings took place when Dr. J. R. Mortlock, Chairman of the Section, visited Cardiff on the 21st March 1960.

The year has, therefore, been a full one, and, as in this year our autumn visit will coincide with the visit of the Supply Section to Cardiff, it is hoped that members of the Group will feel that the year has been in all respects eventful. N. C.

Judging by the above accounts, the serious business of advancing the science has been well safeguarded, and it is noteworthy that endeavours to encourage contributors continue. While the off-record discussions which occur in social conditions after meetings considerably benefit the participants, the wider forum of the formal discussion creates greater circulation. May the excellent work of the Groups prosper. F. C. W.

RETROSPECT

Now that the 1959–60 Session is drawing to its close and the programme of meetings has been completed, it may not be out of place to look back and see whether any lessons are to be learned from the Section's activities.

There was the usual full programme of eight meetings, at which the total attendance was 793, the individual numbers varying from 75 to 200 with an average of 99. For the same number of meetings in the 1958–59 Session, the attendance totalled 1151, the numbers varying from 38 to 440, the average being 144, but the meeting at which the attendance was 440 was a rather special event in that it was a joint one with The Institution of Mechanical Engineers, at which Mr. C. M. Cock read his paper on the topical subject of 'The *Deltic* locomotive'.

If this particular meeting is not taken into account, the average attendance at the remaining seven was 102, i.e. about the same as for the last session. There is no room for complacency, however, for a vigorous Section should surely show increasing attendances as the membership increases.

In the previous session there was the very successful symposium on 'The provision of adequate electrical installations in buildings', which attracted a large audience, but circumstances did not favour the holding of a similar conference in the present session, though the papers of that symposium continued to be read and discussed in the Centres.

Discussions

There were some very good London discussions, notably on the paper by Messrs. D. B. Corbyn and N. L. Potter on 'The characteristics and protection of semiconductor rectifiers', but, in general, the discussions lacked spontaneity and far too few members took part. It cannot be emphasized too strongly that, for a Section to flourish, there should always be a reasonable number of members ready to speak, in addition to those selected by the Committee to open and stimulate the discussion. It is not intended that the discussion should be confined to the selected speakers.

Another comment is that all too rarely does the general membership of the Section make nominations for the Section Committee elections, with the result that the Committee's nominees are usually elected. This is not altogether satisfactory, for it is desirable that the Section Committee should be as representative of the Section membership as possible, and this can only be fully achieved by members taking an active interest in the matter by making 'outside' nominations in accordance with the rules and following up by voting in full strength.

Group activities

From the reports of their representatives on the Section Committee and from visits made to them, there is no doubt that the four Groups in the Centres continue to flourish and to play a very active part in the life of The Institution. In particular, mention should be made of the excellent discussions which are such a feature of the Group meetings and which might well serve as an example for the London meetings.

Despite the shortcomings mentioned earlier, the session appears on the whole to have been a reasonably successful one on the technological side, and the two social events—the Annual Dinner-Dance and the summer visit to Oxford—were most enjoyable functions.

It is hoped that in the coming session more members will take an active interest in the work of the Section and its Groups by attending the meetings and social events, taking part in the discussions and, where possible, submitting papers for consideration by the Section Committee, for only in this way can the leadership of the Section in this important branch of the professional electrical engineer's work be assured.

T. E. H.

MEASUREMENT AND CONTROL

THERMISTORS

An 'integrating' paper, entitled 'Thermistors, their theory, manufacture and application', was presented by the authors, Dr. R. W. A. Scarr and Mr. R. A. Setterington, at a meeting of the Section held at Savoy Place on the 5th April 1960, the chair being taken by Mr. W. S. Elliott. A brief article based on the paper appears on p. 538.

Dr. Scarr explained that the thermistor is a temperature-sensitive resistor usually having a large negative temperature coefficient of resistance in the range 1–5% per degC, the law of resistance against temperature being exponential. Thermistors are made from semiconductor materials and consist of a combination of metallic oxides or sulphides; conduction is purely electronic and, if the temperature is unchanged, current is proportional to applied voltage. The structure and mechanism of conduction in a monocrystalline semiconductor are fairly well understood, but this is not so with the oxide semiconductors used in thermistors.

Dr. Scarr described the lengthy processing techniques necessary in the manufacture of thermistors, illustrating his remarks with lantern slides, and concluded by mentioning a wide variety of applications of the device.

Stability problems

An extensive discussion followed, to which 12 speakers contributed. Dr. F. C. Widdis, who opened, stressed the value of the thermistor for measuring small temperature changes in confined spaces, but suggested that a good deal of further study on their stability and reproducibility is desirable. He pointed out that the glass-enclosed indirectly-heated thermistor could be used as a precise a.c.–d.c. transfer device for current measurement over a frequency range from 0·5c/s to 50kc/s with an accuracy better than 1 part in 10^4. He expressed surprise at the high degree of short-time reproducibility he had encountered in thermistors used in this application, the stability being in the region of 0·005°C for an 80°C rise.

Dr. A. J. Maddock commented on the absence of detailed information on the long-term stability of the various modern thermistors and pointed out that such information is of vital importance to prospective users of these devices for temperature measurement. His remarks were strongly supported by Mr. W. H. P. Leslie and other speakers; the opinion was expressed that the mixtures used in thermistors were unlikely to be as stable as pure materials, and this seems to be a case where stability and sensitivity do not go hand in hand.

Low-frequency behaviour

Mr. J. D. Brownlie discussed the behaviour of the thermistor as a circuit-element and explained how, at low frequencies, the thermistor behaves as a large inductive reactance in series with a negative resistance. He described the way in which this property could be used for the generation of low-frequency oscillations below 1c/s. He showed how the problems of non-linear analysis which arise in the use of thermistors at low frequencies could be solved with a digital computer using the Runge–Kutta process, claiming that this technique had marked advantages over analogue methods; a subsequent speaker expressed some doubt on this point.

Dr. A. K. Jonscher spoke of the difficulties of explaining the behaviour of the thermistor in terms of solid-state physics. Since the thermistor is a compacted granular element, it might be expected to exhibit surface-barrier effects, but there is no direct evidence of such. Mr. T. Evans also discussed these problems and expressed the chagrin commonly felt that things like thermistors should be so successful when so little is known about them.

In replying to the discussion, Mr. Setterington gave detailed answers to most of the questions raised. On the predominant question of stability, he pointed out that those contributors who have used thermistors have stated that the stability is quite high, and he suggested that fears on this point really only arise in prospective users who have not had previous practical experience with these devices. He explained that in production the thermistors were expected to repeat their resistance value within 0·1% after ageing at 100°C for a week.

The meeting concluded with a vote of thanks to the authors, proposed by Mr. Elliott.

F. C. W.

News from the Centres

NORTH STAFFORDSHIRE SUB-CENTRE

Revolutionary ideas

A JOINT meeting with the local centre of the Institution of Post Office Electrical Engineers was held at Stone on the 22nd April 1960, when Mr. A. A. M. Whitehead presented the paper on 'The application of transistors to line communication equipment' by Mr. H. T. Prior, Mr. D. J. R. Chapman and himself, illustrating his talk with slides and an interesting display of the equipment utilized.

The discussion, opened by Mr. H. P. Staunton, embraced circuit design, cost of equipment, switching stations for rural areas, and the effect of temperature on the ageing of transistors. The question of perhaps most concern was the operating life of a transistor, but it does not yet seem possible to answer this.

Mr. A. R. Buttrey, proposing a vote of thanks to Mr. Whitehead, said that many of the members present were power engineers who like to attend such a meeting to find out what the light-current engineers are doing. He likened the lecturer to Daniel in the lion's den in trying to sell a new idea which was quite revolutionary compared with the equipment at present dealt with in the Post Office Training School, and it was not surprising that many awkward questions had been asked. He congratulated Mr. Whitehead on an excellent survey and lucid explanation of a complex subject.

Annual General Meeting

The Annual General Meeting was held on the 16th May at Stafford. In his report the Chairman, Mr. A. Asbury, referred to Mr. J. A. P. Firth's resignation from the Committee on leaving to take up a post in Solihull. He thanked him for his services to the Sub-Centre and wished him success in his new appointment. He also thanked Messrs. A. T. Chadwick and J. E. Boul, who had given valuable assistance and support in Committee for many years, and whose counsel and experience will be missed when they leave the Committee at the end of the session. He announced that, as there had been no other nominations, the Committee's nominees were duly elected to the Committee for next session.

Although the attendance at meetings had been reasonably good, Mr. Asbury thought that there was a tendency for members to attend only those including papers dealing with their own speciality. In doing this, he thought, members were losing sight of a principal aim of The Institution which is to spread knowledge of all branches of electrical engineering. He appealed to members to attend more meetings and help to fulfil this aim.

Modesty of Graduate members

Commenting on the satisfactory increase in membership, he directed attention to the proportion of full members, which is only 6% against the national average of 9%. On comparing with other Sub-Centres, he found a strong indication that we may have a number of Associate Members who should be applying for full membership. He also noted that we have a larger proportion of Graduates than is usual. Here he felt that the more stringent requirements and the modesty of our Graduates undoubtedly play a part.

At the Ordinary Meeting which followed, the Chairman formally welcomed three new Corporate members and then invited Messrs. D. B. Corbyn and N. L. Potter to present their paper 'The characteristics and protection of semiconductor rectifiers', in which they discussed the basic characteristics of these rectifiers and the special properties required of h.r.c. fuses suitable for this application. The authors were members of the Sub-Centre, Mr. Potter being one of those formally welcomed that evening.

Dr. T. E. Calverley opened the discussion, to which about a dozen members contributed. The vote of thanks was proposed by Mr. H. Baker, who expressed appreciation for an excellent paper and complimented the authors on the authoritative way in which they had dealt with the discussion. This, he thought, was often found to be more of an ordeal than usual when presenting a paper before one's own colleagues.

The Chairman announced that the Annual Dance would be held on the 14th October 1960. This would be much earlier than usual in an attempt to avoid clashing with other events, and members were requested to note and reserve the date.

Colliery visit

During 1960, Stoke on Trent is celebrating its Golden Jubilee, i.e. the 50th anniversary of the federation of the six towns to form the county borough of Stoke on Trent, which has since reached city status. In connection with the Jubilee, the National Coal Board organized an exhibition and open fortnight at Hem Heath Colliery, and members of the Sub-Centre were invited to view the exhibition and inspect the surface equipment of the colliery on the 21st June.

Visitors first made a leisurely tour of the exhibition, which illustrated by working models, photographs and items of actual equipment all aspects of coal-mining, from locating the seams to the most modern methods developed for getting the coal, transporting it underground and raising it to the surface, and screening and washing it in preparation for sale. Scientific equipment for the analysis of the coal and of the gases in the mine air and for various other purposes was displayed, together with an exhibit on safety in the mine and a selection of modern appliances for the efficient use of coal.

The party was then divided into small groups, each being escorted by a guide to view the surface equipment of the colliery in working conditions. Reconstruction is nearing completion to enable this colliery to raise 1¼ million tons per annum, of which half a million tons would be raised from a depth of 1062 yd.

The winders, air compressors and ventilating fans are driven by motors ranging in size from 1500 to over 3000 h.p.,

while some 3500h.p. of motors is installed in the coal-preparation plant. On completion, the colliery will take about 10MVA of load at 33kV.

The visit proved most interesting and instructive, and thanks are due to the National Coal Board and the area and colliery staffs for the opportunity to see this modern installation, for the excellent arrangements made, and for the untiring patience of the guides in explaining the operation of the equipment and dealing with the many questions raised.

L. G.

SOUTH-WESTERN SUB-CENTRE

Summer Meeting

On the 9th July 1960, 100 members and guests visited the Hinkley Point atomic power station site. Fifty travelled by train from Plymouth and Exeter to Taunton, where coaches were waiting to convey them to Hinkley Point. The remainder of the party travelled direct to the site by private cars.

After coffee, each visitor was issued with a regulation helmet, and the conducted tour of the fabrication area was begun with the help of several guides. Later the party adjourned to the staff restaurant where they were entertained to lunch by the English Electric Co.

The second tour, after lunch, included a visit, by means of the lift, to the top of the heat exchangers. On returning to ground, an inspection was made of the turbine house, where only the condenser equipment below level was installed.

The party returned to the restaurant for tea, and this time we were the guests of the C.E.G.B. After this welcome rest from touring the spacious site, the Sub-Centre Chairman, Mr. A. G. R. Bell, thanked Mr. R. Wall, resident engineer of the English Electric Co., for arranging the visit, Mr. H. S. Davidson, controller, South Western Division, and Mr. S. Prior of the C.E.G.B. who organized the guides and restaurant services.

Although the weather was stormy for the earlier part of the tour, which was mainly out of doors, the sun broke through in the afternoon, and this made the return coach journey to Taunton via the Quantocks very enjoyable.

Although the stage has not been reached where the main electrical equipment can be installed, the visitors were impressed by the massive engineering structures, which, of course, include the Goliath crane. Some of the party had left home in West Cornwall shortly after dawn, and would not return until the late evening, but everyone agreed that it had been a very interesting and enjoyable day.

W. G. C.

News from abroad

QUEENSLAND OVERSEA COMMITTEE

Brisbane thunderstorms

On the 8th April 1960, our members were invited by the Institution of Engineers, Australia, to a lecture by Prof. S. A. Prentice entitled 'Thunderstorms in the Brisbane area'. This was the second time that Prof. Prentice had spoken on thunderstorm activity and served the purpose of bringing his audience up to date on the results of much research carried out under his direction at the University of Queensland.

As Brisbane is in an area of relatively high thunderstorm activity, a lightning observatory has been established on the roof of one of the university buildings. From this, and from reports received from meteorological observation posts in the immediate and distant hinterland, a large volume of data is collected and dissected. In addition, the facilities of the excellent university high-voltage establishment are available for laboratory work in the same field.

In his paper, which appears in full in the March 1960 issue of the *Journal of the Institution of Engineers, Australia*, Prof. Prentice devoted the first part to records of occurrence of storms in the Brisbane area and to the lightning fault rates for transmission lines in this and surrounding areas, and the second part to a survey of lightning-stroke counters and a procedure for checking their performance.

The audience, which numbered approximately 100, included a very strong representation from the electricity supply authorities.

Testing of h.v. equipment

On the 19th May, the Committee arranged a meeting at which Mr. T. F. Monahan delivered a paper on the subject of 'Impulse testing of high-voltage equipment'. Mr. A. S. Faulkner presided and welcomed the large number of visitors who were present.

Mr. Monahan, who has presented papers to The Institution in England on surge phenomena, has recently been transferred to Australia to supervise the installation of high-voltage testing equipment at a transformer factory.

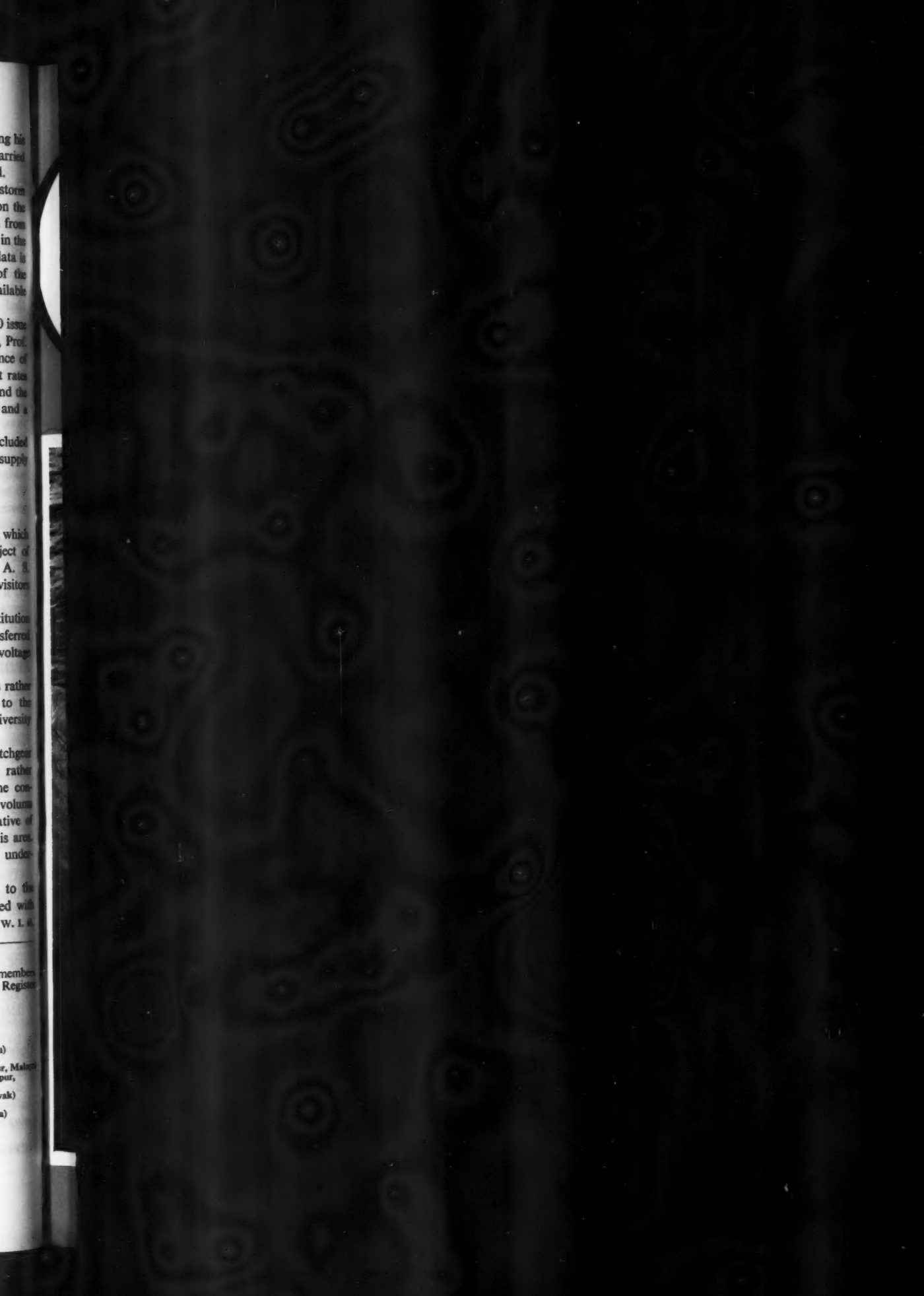
He concerned himself with prescribed impulse tests rather than with fundamental research, calling attention to the advanced research work already undertaken in the University of Queensland high-voltage laboratories.

He spoke generally of testing procedures on switchgear and transformers and made special mention of the rather difficult problem of interpretation of results. At the conclusion of his paper, he dealt expertly with the large volume of discussion from an audience that was representative of supply authorities and electrical manufacturers in this area. It is worthy of note that a number of members had undertaken journeys of over 100 miles to be present.

The meeting was closed after a vote of thanks to the speaker, moved by Mr. J. E. Moorwood and carried with acclamation.

W. I. G.

OVERSEA ATTENDANCE REGISTER

DURING the period 18th July to 16th August 1960, these members called at the Institution building and signed the Attendance Register of Oversea Members:

BATTEN, A. D. (Port of Spain, Trinidad)
BAYLIS, H. W. (Port of Spain, Trinidad)
BOGLE, R. K. (Penang, Malaya)
DE KRETSER, C. R. (Bukuru, N. Nigeria)
DONOGHUE, V. (Tripoli, Lebanon)
GREAVES, S. (Aden)
GUELKE, R. (Cape Town)
VON HIRSCHFELD, P. A. (Salisbury, S. Rhodesia)
JINKS, C. E. (Florida, Transvaal)
LYDDIARD, J. A. (Kumasi, Ghana)
MANSON, M. W. (Nairobi, Kenya)
ONDER, K. (New York)
PAJAK, S. W. (Los Angeles)
PUGSLEY, E. R. J. (Baghdad)
ROACH, B. M. (Hong Kong)
SOHONI, K. V. (Bombay)
STANDEN, M. H. L. (Khartoum)
THACKER, M. S. (New Delhi)
TRAFFORD, W. (Kuala Lumpur, Malaya)
WARDROP, F. R. (Kuala Lumpur, Malaya)
WOOD, H. J. (Kuching, Sarawak)
WOTTON, E. G. (Toronto)
WYATT, G. E. (Lagos, Nigeria)